Melvin Butte Vegetation Management Project

Forest Vegetation Specialist Report

Sisters Ranger District

Deschutes National Forest

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Introduction

The Melvin Butte Project includes 5,376 acres within the 97,508 acre Deep Canyon watershed. The project elevation ranges 2000ft from 4240ft to 6280 ft. with elevation highest in the southwest and lowest towards the northeast. Two buttes alter the interior elevation trend of the project area and are Melvin Butte and an unnamed butte (see figure XX). Common to the region, precipitation trends follow elevation gradients with higher elevations receiving higher precipitation (20-40" year Avg. with most of lower elevations receiving this as rain).

The project area is bounded by private lands on the east (primarily the Cascade Timberlands- Skyline Forest), by Bend/Fort Rock Ranger District to the south, Pole Creek Fire (2012) rd. to south and west, Whychus creek to northwest and by the Sisters Area Fuel Reduction (SAFR) Environmental Assessment (EA) decision (2009) to the north (legal: T16 and17S, R9 and 10E, all sections, Willamette Meridian, Deschutes County, Oregon).

This vegetation report describes the Purpose and Need, existing forested conditions[1], trends, effects of proposed vegetation treatments and past, present and foreseeable future actions. The project area was stratified into potential treatment and retention areas based on soils information, current dominant vegetation type, density[2], trajectory, presence of abundant mistletoe, past clear-cuts (plantations), wildland urban interface (WUI) and visual corridor considerations.

This report tiers to the larger scale Whychus Watershed Assessment which describes the recent disturbances and conditions present and the need for action on the watershed scale (revised in 2013[3]). The Whychus Watershed Assessment (USDA 2013) was used to shape the desired future conditions and the proposed action for active forest management within the Melvin Butte project area analysis boundary.

This report has four primary purposes:

1. To provide background information necessary to evaluate the goals and objectives of the Purpose and Need for action, and compare the effects of no action and alternatives to the proposed action on forest vegetation.
2. To disclose the existing condition of forest vegetation and fuels and likely trends relating to forest health.
3. To provide supporting evidence/analysis that the proposed action and alternatives are consistent with the Purpose and Need, Forest Plan, Watershed Analysis, laws, regulations, and policy.
4. To address key issues raised during scoping that are pertinent to active forest management.

[1] Presented as structural and seral state, fire hazard, density, dwarf mistletoe abundance, species composition, and more.
[2] Tree density measured as the number of tree per acre (TPA), cross sectional tree area (called basal area measured in square feet per acre (BA/acre)) or canopy cover (% vertical cover).
[3] The 1998 Whychus Watershed Assessment was revised twice (2009 and 2013), in part, to account for large scale-changes in the watershed due to fires and insect outbreaks.

Summary of Effects

Alternative 1 – No Action

Direct and Indirect Effects

There are no treatments under the no action alternative, and therefore no direct or indirect effects.

Forest Ecosystem Restoration

Stand Structures/Species Composition

Structures remain at a high risk for a large proportion of the area to have stand replacement fire. Species composition remains disproportionally askew to fire intolerant species (when compared to HRV) due to interactions of past management (fire suppression/exclusion and past timber practices). Plantations lack spatial heterogeneity and are beginning to show various levels of dwarf mistletoe.

The no action fails in moving structure or species composition within the project area towards the Forest Plan Standards/Guidelines (amended by Northwest Forest Plan), Watershed Analysis goals, or the desired future condition.

Stand Density

Stand densities would remain at high levels and generally increase over the next 30 years under No Action. Large old ponderosa pine would continue to attenuate with replacement challenged by interactions of inter-tree competition, dwarf mistletoe and bark beetles.

Insects and Disease

Current stand densities are at or above the upper limit of the desired range of percent of maximum SDI over 88% of the planning area. As stands remain at these high densities, mortality from insects and disease are expected to increase. Of particular concern, western dwarf mistletoe, in the planning area is expected to increase by expansion into plantations and other areas where levels are moderate to low. Large tree recruitment is expected to be reduced as infection levels rise in and effect height and diameter growth.

Fire Hazard

Summer precipitation and temperature play large roles in determining the effects of a given fire season. Reduced snowpack and warmer summers are expected to lead to longer fire seasons with increased severity and increases in area burned. Increased potential for type conversion and species conversion is expected as well. A two to three fold increase in area burned is projected in the eastern Cascades of Washington by 2080 (Littel et al. 2010). This threat is amplified by the observation that the entire western United States has experienced higher large-wildfire frequency, longer wildfire durations, and longer wildfire seasons since the mid-1980's (Westerling et al. 2006).

Current fire hazard analysis (herein and Fuels report) indicate a high fire hazard risk. Fuel accumulations, along the 16rd, private land, and within stands, indicate continuity and/or suppression (ease of control) challenges.

Alternative 2- Proposed Action

Direct and Indirect Effects

Effects on Forest Ecosystem Restoration

Stand Structure and Species Composition

Alternative 2 thinning and fuels treatments would move stands towards reference conditions. All treatments would lead to a greater patchwork distribution of size/age classes rather than the current continuous vertical and horizontal distribution of trees. Early seral, fire climax ponderosa pine species composition is improved by the number of acres treated which includes areas where this is the focus strategy (i.e. mixed conifer group openings).

Stand Density

On the project (Melvin Butte landscape) level, SDI moves from 88% max SDI (pre-treatment) to 44% max SDI (after thinning). This proportion change represents movement to between the lower and upper management zones for forest health. While specific areas within the project are still above the UMZ (60% Max SDI) (Table 21,22) and has sustained risk for insects/ disease and fire, other areas near or surrounding these are within the zone predicting these factors to be less likely. Plantation stands have received greatest release and are expected to develop into large trees more rapidly.

Insects and Disease

Variable thinning to lower SDI values and move stands towards reference conditions will have a positive effect on tree resilience against bark beetles and lightly (DMR1-3) infected dwarf mistletoe ponderosa pine. On the project level, dwarf mistletoe abundance is reduced by half and in 30 years levels are approaching the no action as mistletoe spread has impacted regeneration and other under/midstory trees. However, on the fine-scale (stand level), it is expected that strategic removal, pruning and girdling of point source locations including select large trees will aid in size development of ponderosa pine in fine-scale locations especially plantations and areas at least 100 ft. from mistletoe infected trees.

Fire Hazard

Under the proposed action, the potential for crown fire is greatly reduced across the project as a whole (treated and untreated areas) as thinning, fuels work, underburning raises CBH and decreases CBD. These changes increase the CI and reduces the potential for crown fire in all PAGs. Although, no treatment and retention areas maintain high CBH, CBH, acres treated show a marked decrease in the likelihood for stand replacement fire. Active crown fire is predicted to occur on 10% of the project area which is primarily allocated to retention strategy and no treatment areas. Alternative 2 greatly reduces the predicted mortality within treated areas, by changing the majority of the potential fire type acres to surface and passive crown.

Alternative 3- Proposed Action Modified

Direct and Indirect Effects

Stand Structure and Species Composition

There would be little difference in stand structures between Alt. 3 and Alt. 2 as stands are variably thinned from below lowering stand densities and reducing competition to larger trees. Treatment acres designed to address the effects of past selective logging and fire suppression (species composition implied) in the mixed conifer PAG by improving fire-tolerant localized ponderosa pine growing areas would be dropped. As a result, and in order to maintain stocking, fire intolerant species proportions would be retained. About 30% of the 835acres (250 acres maximum) would be maintained under a fire intolerant dominated trajectory.

Stand Density

On the project (Melvin Butte landscape) level density measures for Alt 3 are similar to Alt 2, SDI moves from 88% max SDI (pre-treatment) to 48% max SDI (after thinning). The 4% increase (from Alt. 2) is a result of treatment acres being dropped and altered. As a result, 321 acres are kept at higher densities with more of a fire intolerant tree composition with 71 acres directly next to private land.

Insects and Disease

Thinning to lower SDI values and moving stands towards reference conditions will have a positive effect on tree resilience against bark beetles and lightly (DMR1-3) infected dwarf mistletoe ponderosa pine.

On the project level direct and indirect effects of dwarf mistletoe among Alt 3 and Alt 2 are similar (table 23, 32). At the project level dwarf mistletoe rating is reduced by about 1/3rd from existing levels and in 30 years those levels return to slightly below the no action for that year (table 23, 32). On the stand-scale overstory influences into plantations and small medium small trees are maintained as large trees continue to provide mistletoe point source locations. Retaining any small trees underneath or adjacent to, highly infected ponderosa pine trees decreases the likelihood for large tree development (Eglitis et al. 2014). Overtime infestations will spread down, out and within infecting more and more of the plantations and adjacent area. Under this alternative managing for young ponderosa pine or replacement near highly infected trees, of any size, is challenged by reduced height/ diameter growth.

Fire Hazard

On the landscape as a whole, crown fire potential is reduced from no action though would be slightly higher than the Proposed Action. This difference from the proposed action is due to the reduction in treatment acres and type within the ponderosa pine and mixed conifer types. Access to about 70-90 acres of restoration units would be avoided with over much of this land directly interfacing with private land (2/3rd mile). As such, potential fire behavior and influences (egress) in these areas would be less predictable as current crowns have both horizontal and vertical fuel connectivity.

Overview of Issues Addressed

Past selective and clear cutting, altered fire regimes, recent fires and insect and disease agents are the major contributors to forest health issues and the need for action within the Melvin Butte project area (USDA 2013). These elements interact to affect the planning areas ability to be resistant and resilient to disturbances in the short- and long-term (Littel et al. 2010, Stine et al. 2014, DeRose and Long 2014, USDA 2013, Pole Creek Fire 2012).

Fire suppression/ exclusion has interrupted the low to mixed-severity fire regimes, leading to a change in forest structure, species composition, densities, fuel accumulation and increased insect and disease abundance. Past selective logging (circa 1950s and 60s) has removed a large proportion of the large tree ponderosa pine component from both the ponderosa and mixed conifer types. The recent past beetle outbreak (circa 2000s) and 2012 Pole Creek Fire has created abundant standing and down wood along the 16rd affecting visual experiences, off road travel for firewood utilization and potential fire suppression safety/challenges along a WUI escapement corridor. Regeneration cuts have created over a thousand acres in the planning area as small evenaged blocks dominated by pole-sized trees. About 2/3rd of the planning area has various fine- to broad-scale levels and locations of ponderosa pine dwarf mistletoe influencing the ability of these areas to develop large tree structures. As a whole, the project area contains a high density of ladder fuels from small trees and understory shrubs which contributes to stand replacement conditions in the event of a fire (Pole Creek Fire 2012). Species composition is a factor influencing the risk and stability of forests in the planning area.

The aforementioned items have recently (years 2002-2012) interacted (among other factors) on the landscape to influence the outcomes of the numerous fires within the watershed ((USDA 2013), Table 1).

Table 1. Fires greater than 10 acres in the Whychus Watershed project area since the original watershed analysis of 1998.

Fire Name	Year	Total Size (acres)	Watershed Project Area (acres)
Cache Mountain	2002	4,358	43
Black Crater	2006	9,411	9,396
Lake George	2006	5,537	1,857
GW	2007	7,349	954
Steven Canyon	2008	173	76
Black Butte II	2009	578	559
Rooster Rock	2010	6,119	6,119
Alder Springs	2011	1,449	1,052
Pole Creek	2012	26,119	26,119
Total		61,093	46,175

Most of the plantations that were established after clear cutting beginning in the 1960's and 1980s, are now in need of stand tending to reduce dwarf mistletoe, improve growth and move them towards a stand structure in line with reference conditions.

High abundance of ponderosa pine western dwarf mistletoe threatens key structural components and future large ponderosa pine tree development. Lodgepole stands continue to fall apart creating large amounts of down wood and fuel continuity to adjacent stands. Outside of plantations, interruption of fire regimes has led to the dominance of late seral conditions (increased grand/white fir and/or ingrowth of ponderosa pine) with an increase of dwarf mistletoe and mountain pine beetles. Recent past regeneration (plantations) activities that were designed to reduce mistletoe levels have created reduced mistletoe "areas", but lateral spread from adjacent stands has infected into stand boundaries.

The need for forest restoration includes reducing the potential for severe wildfires, and promoting stand densities necessary to maintain desired forest conditions during drought. Restoring forest conditions in concert with ecosystem management principles would promote resistance and resilience of these areas thereby, improving their ability to recover, function and to develop in ways that were characteristic of the respective types following disturbances from fire, insects, and disease.

The need for active management will be evaluated in terms of current conceptual frameworks and historic reference conditions.

Purpose and Need Indicators

The purpose of this project is to maintain and restore resiliency and forest health in stands that provide habitat for interior forest wildlife species and present a potential risk of large scale wildfires in the Melvin Butte area.

There is a need to reduce fuel loadings and forest vegetation density to lessen the risk of large wildfires to nearby communities and key ecosystem components, such as large old trees. Recent large wildfires have dramatically changed the landscape leaving the project area isolated and thereby increasing the urgency of protecting the remaining forest.

The project area is currently at risk of stand replacement wildfire associated with insects, disease, and overstocking and represents some of the remaining unburned forest in the area. This project would also meet a need to provide wood products to the local and regional economy as a byproduct of landscape level treatments.

This action responds to the goals and objectives outlined in the Deschutes National Forest Land and Resource Plan, and helps move the project area towards desired conditions described in that plan. The Whychus Watershed Analysis provides a framework to conduct vegetation management activities in the project area.

Objectives

- Create stand structures more consistent with reference conditions of species composition, structure, and age/size classes, and improve resistance and resilience to disturbances.
    - Indicators: Basal area per acre, percent of maximum stand density index (SDI), canopy base height, surface fuels, and species composition

- Reduce effects of insects and disease in order to increase longevity of mature and old forest and promote growth of younger age classes.
    - Indicators: percent of maximum stand density index (SDI), species composition, dwarf mistletoe rating

Methodology

Sources of Information

Vegetation Layer

The NRIS vegetation polygon layer was used as the base layer for classifying vegetation. There are 203 polygons within the planning area, with 23acres representing non-forest types.

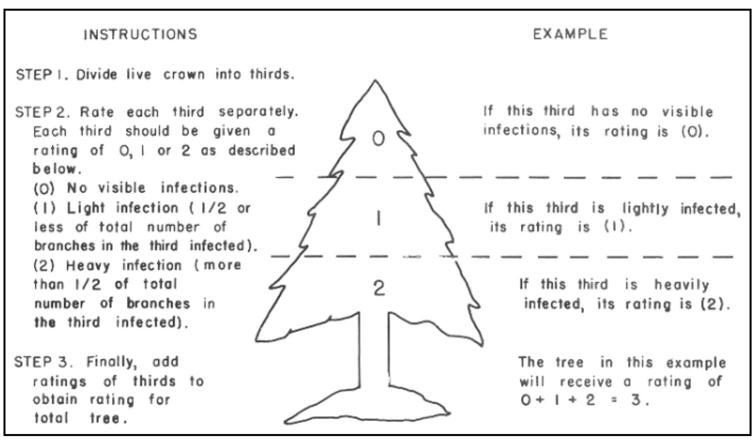
Stand Exams

A total of 26 formal stand exams were taken in the planning area from 1998 to 2008. The majority of the stand exams were conducted in 1998. For modeling, the FVS program grows all stands to a common starting year for simulation (see Analysis Methods, below).

Walk-through Surveys

District personnel conducted walk-through surveys of most stands from 2012-2015. These personnel included doing mistletoe assessments and mapping using Hawksworth rating system (1977, Figure 1) or stocking surveys in areas that overlapped with the Pole Creek Fire 2012. Items noted included species composition, live/dead, number of canopy layers, insects/disease, plant associations, tree density, and potential treatment options.

Figure 1. Determining Dwarf Mistletoe ratings (DMR) using the 6-class Dwarf Mistletoe Rating System



GIS Layers

The following GIS layers were used in development of the existing condition, proposed action, and effects analysis: roads, streams, 2014 NAIP imagery, Lidar, GNN, Pole Creek BARC information and management areas.

Forest Health Protection Surveys

Formal site visits by Forest Health Protection area entomologists and pathologists occurred at different times over the summer of 2014. A report letter dated January 14th, 2015 by Andris Eglitis, Brent Oblinger and Helen Maffei can be found in the project record.

Development of Proposed Action Treatments

The stand reconnaissance information was used along with stand exam data summaries, Gradient Nearest Neighbor, GIS layers, and aerial photography to develop the proposed action treatment on a stand by stand basis. The proposed action maps (Alts 2 and 3) are the result of stands aggregated into general stand conditions and treatment types.

Analysis Methods

Nearest Neighbor/FSVeg Spatial Data Analyzer (SDA)

A computer program called Nearest Neighbor (NN) was used to assign stand exam data (reference stands) to the stands without stand exam data (Crookston et al. 2002). NN analysis uses satellite imagery (2014 Landsat TM data), spatial relationships, and topographic information to match target stands without data to the most similar reference stand with data. Tree data from the reference stand is then assigned to the target stand without data (imputation). Target stands with a statistically poor match to any reference stands were in the less well represented forest types and/or stand-types. One hundred and fifty-four reference stands were used to assign the missing data to non-examined stands. Table 2 displays the acres with adequate NN matches or reference data (NN-Ok or CSE) and the number of acres with a poor match (NN-Poor). Overall, the NN imputation quality very good at approximately 90 percent- out of 1466 imputations, 155 represented large differences between reference and target stands (see Appendix C).

The SDA program is an ArcMap extension developed by the Forest Service that allows landscape simulations using data assigned by the NN program. The Forest Vegetation Simulator (FVS) was run within the SDA shell, and results can be viewed both visually and in summary output form.

Table 2. Data sources for forested polygons by PAG

PAG	CSE Acres	NN-Ok Acres	NN-Poor Acres	Total Acres
Ponderosa pine wet	160	20	0	181
Ponderosa pine dry	510	433	0	942
Mixed conifer wet	319	1191	58	1568
Mixed conifer dry	729	1253	141	2123
Lodgepole pine dry	0	2	16	18
Lodgepole pine wet	0	378	134	512
Mountain hemlock dry	0	0	8	8
Total Acres*	1718	3277	357**	5352

*Note 23 are in non-forest/ non-vegetated types
**A large part of poor imputed acres are a result from condition changes due to Pole Creek fire of 2012, pre-fire condition stand exams and a low number of lodgepole PAG reference stands. Stocking surveys or walk through surveys were used to fill in information that the model represented as erroneous.

Forest Vegetation Simulator

Stand Simulations

The South Central Oregon and Northeast California variant of the Forest Vegetation Simulator (FVS) (Keyser comp. 2014) was used to process stand exams to give the current stand conditions and to simulate thinning treatments and project alternatives for a 40 year time horizon. FVS is used here to compare treatment effects among alternatives and not for absolute results. The Fire and Fuels Extension (FVS-

FFE) (Rebain 2010) was run to model potential fire metrics for current conditions and after thinning treatments. FVS-FFE was also used to simulate underburn fuels treatments associated with thinnings as well as the stand-alone underburn treatments. Areas that did not have scheduled treatments (i.e. retention areas) were run without treatments to the end of the projection.

For modeling treatment areas, all thinning treatments (both Alts.) were scheduled in 2016 with underburning scheduled in 2018. Yardloss was scheduled with any thinning to simulate the removal of fuels (to occur by piling, lop scatter, etc.) associated with the thinning. Thinning outside of; plantations, burn only areas, lodgepole improvement area and scenic views enhancement used Thinpt keywords using a general 80 BA target. The point-thinning method (ThinPt keyword) thins each sample point in a stand to the residual target. This means that dense areas in the stand are thinned to the target density, while areas already below the target are not thinned. This method is more representative of how stands are actually thinned in practice. The end result is that since the denser sample points are thinned to the target density the overall stand average is usually below the residual target due to sample points falling in under-stocked areas and openings. Eighty basal area was used since it corresponded to the middle of the management zone at QMD. Alt. 3 modeling was developed to respond to key issues. Alt. 3 mimicked Alt. 2 in all aspects except having mixed conifer group openings and large tree removal for dwarf mistletoe removed from the model.

Stand Density/Stand Density Index (SDI)

Current and future estimates of stand density and SDI were computed from raw stand exam data entered into the FVS program. All plots were used, and there was no manipulation of the raw data. Maximum SDI values used to model tree growth and mortality are determined by plant association and are set by GBA or CVS plot analysis (Figure 2, Volland 1988, Simpson 2007, Keyser comp. 2014). Where more than one plant association crossed a stand boundary a majority rule was used to assign the MaxSDI values. The threshold to evaluate treatments were based on the lower and upper management zone (see below for discussion).

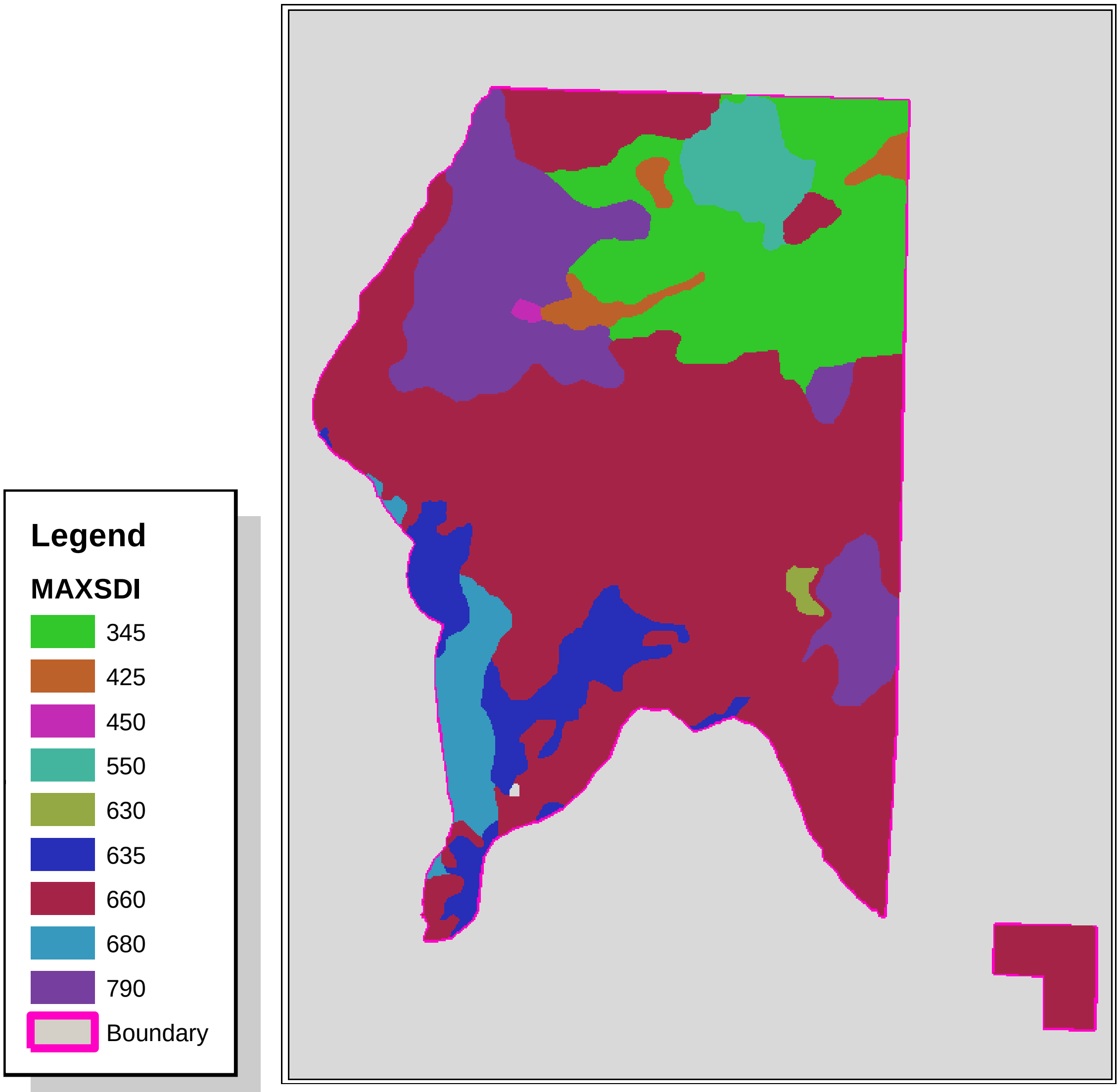


Figure 2. Map corresponding to MaxSDI values used with the Forest Vegetation Simulator. Stands were adjusted to account for differing site potential and in general follows the precipitation gradient.

Fire Modeling

The Fire and Fuels Extension (FVS- FFE extension) was run using the potential fire keyword for severe (90th percentile) weather and fuel conditions (Table 3). Stand-alone underburning was scheduled in 2018. Fuel modifications were scheduled after thinning treatments in 2016.

Table 3. Fuel and weather parameters used in fire behavior modeling

Fuel Component	Percent Moisture Content	Weather Component	Value
1-hour Time lag	2	Temperature	87 Degrees F
10-hour Time lag	3	Rel. Humidity	13%
100-hour Time lag	6	Wind	14 mph
1000-hour Time lag	8		

Live woody Fuels	98
Herbaceous	19
Duff	20

Output potential fire metrics from FFE included canopy bulk density, canopy base height, flame lengths, crowning index, fire type, and mortality.

Products

The following FVS output products were used in the analysis of alternatives:

1. Stand density metrics
2. Thinning results
3. Canopy height (CBH), canopy bulk density (CBD), and mortality under severe conditions (90th percentile)
4. Predicted fire type (active, crown conditional, passive, surface)

Limitations

Limitations of the FVS model in this instance include the following:

1. Limited ability to simulate desired stand conditions in terms of spatial heterogeneity
2. Modeling spatial dwarf mistletoe prescriptions, i.e. individual tree removal, in a non-spatial model.
3. Under-prediction of crowning potential versus empirical observations (Cruz and Alexander 2010)
4. Mortality[4] estimates from FVS-FFE are based on the potential fire type (surface, crown, conditional crown) and are best used as a means to compare the effects of alternatives rather than absolute values.

Forest Plant Associations and Plant Association Groups (PAGs)

Plant community classification in the Pacific Northwest Region follows guidelines established in FSH 2090.11 (USDA Forest Service 1991). It is founded on the concept of "Potential Natural Communities" (PNC) (Hall 1998). PNCs are "The biotic community that would be established if all successional sequences of its ecosystem were completed without additional human-caused disturbance under present environmental conditions. Grazing by native fauna, natural disturbances such as drought, floods, wildfire, insects and diseases, are inherent in the development of potential natural communities which may include naturalized non-native species." (FSH 2090.11, USDA Forest Service, 1991).

In the Pacific Northwest Region, the term used for potential natural communities is "plant associations" (Hall 1998). Plant associations for the Pacific Northwest Region are described without considering disturbance caused by natural elements (as well as human-caused disturbances), including historic fire

[4] In the context of FVS, tree mortality is derived from two main sources: exogenous (external) agents such as insects, diseases, and fire, and endogenous (internal) mortality. Endogenous mortality has two sources: background mortality and density-dependent mortality (Dixon 2009, Powell 2014).

regimes/ processes (Hall 1998). Consequently, a plant association is composed of species that will be most competitive over time (climax species) and these species will prevent the establishment of less competitive species (seral species) under current climate and site conditions (Hall 1998, Volland 1988, Simpson 2007). Indicator grasses, forbs, shrubs, trees are used to evaluate the area of the plant associations. Plant associations within the Melvin Butte project area were determined through field and GIS mapping.

The associations were then grouped by their climax species, soil, site potential, temperature and moisture similarities into Plant Association Groups (PAGs), using categories listed in the Deschutes Watershed Evaluation and Analysis for Viable Ecosystems (USDA1994, Volland 1988, Powell 2007, Simpson 2007). This information also provides broad-based comparison to historical range of variability (see HRV below).

Forest Size/Structural and Seral Stages

A Viable Ecosystems analysis was conducted to determine the size/structure and seral status of the project area. The process used GNN vegetation data on a 30meter pixel and categorized and cross referenced the pixel to a match (nearest neighbor process) from Forest Inventory and Analysis data. Tree information, species dominance and density are evaluated and assigned. The pixels are stratified by plant association group and run through a filter based on species, size and density thresholds. The result is a seral and structural relationship for each pixel. This information was used to inform/ compare the project to the broad-scale HRV watershed condition (USDA 2013).

Historic Range of Variability

Historic Range of Variability (HRV) is a term used to describe the natural fluctuation in pattern of components of ecosystems over time (Stine et al. 2014). HRV serves as a framework of understanding the ecological system in question and serves as a general reference point useful for setting management goals (Landres et al. 1999). The assumption is that past conditions and processes can provide context and information (today) and that these disturbances drove variability in all ecological systems.

In this project, HRV is used as reference framework for historical estimates of forest size-classes (structure) and seral stages, tree species (or lack of) proportion dominance, that may have been present at any given point in the past 100-300 years (Oliver and Larson 1996, O’hara 2001, Franklin et al. 2013). Active forest management described herein includes knowledge-use of historic disturbance processes to evaluate the project area. The Whychus Watershed analysis (USDA 2013) provides range estimates of structure and seral status by plant association group. The Whychus Watershed Analysis (USDA 2013) determined that recent disturbances (i.e. bark beetle outbreak, wildfires) have created changes to size/structure, composition (seral status), and fire hazard of the watershed outside of HRV ranges.

On the Deschutes National Forest the “Viable Ecosystems” approach is used to categorize both size/structure and seral status by plant association group useful in comparing to HRV ranges (USDA1994).

Affected Environment

Existing Condition

Landscape Overview

The historic conditions of the vegetation in the Melvin Butte project area and surrounding landscape is described in the Sisters/Whychus Watershed Analysis and can be found on file at the Sisters Ranger District (USDA 2013). An objective identified in the Whychus Watershed Assessment is to keep species within a historic range of variability (HRV) depending on the plant association, specifically referring to the amount of fire intolerant species such as western juniper and grand/white fir in ponderosa pine and mixed conifer plant associations. HRV used within the watershed is used to assess broad forest health conditions. The watershed analysis also identified density and insect and diseases as factors to larger watershed health.

Plant Association Groups (PAG)

Ponderosa Pine Plant Association Group (21% of area). In this plant association group, ponderosa pine is the main seral and climax species, growing in small, even-age groups or as fairly uniform second growth. Minor amounts of western juniper, lodgepole pine, grand/white fir and Douglas-fir may be present.

These plant associations tend to have a limited grand/white fir component and tend to be ponderosa pine dominated throughout development (Volland 1988, Johnson 1990, Powell 1999, Simpson 2007). On a broad-scale, fire clearly was an important part of large ponderosa pine tree development and played an important role in retaining low densities. Ponderosa pine plant associations were historically dominated by large ponderosa pine, which are more resistant to fire, disease, and insects than western juniper, grand/white fir and incense cedar. A reduction of western juniper, grand/white fir in this project area can help move toward species composition more within the historical range of variability.

The effects of the alternatives on species composition are difficult to quantify, but in general, the more acres treated the greater the shift will be toward fire-tolerant/adapted ponderosa pine.

Mixed Conifer Plant Associations (69% of area): In this plant association group, ponderosa pine is the major early seral species, with grand/white fir as the main climax species. Minor amounts of lodgepole pine, Engelmann spruce may be present. Mixed conifer plant associations were historically dominated by ponderosa pine with minor amounts of grand/white fir, lodgepole pine and Douglas-fir[5]. The structure of mixed conifer patches was formed by a mixture of disturbance severities (Stine et al. 2014, Hessburg et.al. 2007). Ponderosa pine is more resistant to fire, disease and insects than grand/white fir and lodgepole pine. A reduction of grand/white fir and lodgepole pine in the project area can help move toward species composition more within the historical range of variability.

The effects of the alternatives on species composition are difficult to quantify, but in general, the more acres treated the greater the shift will be toward fire tolerant/adapted ponderosa pine.

Lodgepole Pine Plant Associations: Lodgepole pine plant associations are found over a minor portion of the project area (approximately 10%). This vegetation type is found mostly along the 16rd. The areas

[5] Douglas-fir is not a major component to the current species mixture (<0.001% of all trees). This is attributed to inherent soil properties (Pers. comm Terry Craig- soil scientist DNF).

where lodgepole pine is climax tend to have poor cold air drainage, or soil or moisture conditions that other species can't tolerate. Generally, in the lodgepole pine plant associations, lodgepole pine is the early and late seral species replacing itself on a boom and bust cycle of insects and fire. Currently, lodgepole pine is the dominant species on most acres, however, there are some stands that have a component of grand/white fir and mountain hemlock. Most of the area has either been burned over by the Pole Creek Fire or has a large portion attacked by mountain beetles during the 2000s. These areas coincide with visual- and/or designated wildland urban interface (WUI) escapement corridor (16rd).

The effects of the alternatives on species composition within the lodgepole pine plant associations will be minimal since the early and late seral species is lodgepole pine.

Mountain Hemlock: Mountain hemlock plant associations are found over a small portion of the project area (approximately <1%) at the higher elevations. In this plant association, lodgepole pine is the major early seral species and sub-alpine fir, whitebark pine, and western white pine are minor early seral species. This minor inclusion overlaps with the boundary of the Pole Creek Fire 2012 and is currently in in the grass/forb stage with high accumulations of standing and down wood along a visual and escapement corridor. These areas coincide with visual- and/or designated wildland urban interface (WUI) escapement corridor (16rd).

Meadow: Meadow plant associations are found on approximately <1% of the project area and are associated with Three Creeks creek in the southern portion of the project area. The plant associations found within this type are described in Kovalchik (1987) and are grass dominated seasonally wet/dry meadows. No treatments are proposed in this association.

Table 4. Plant Association Groups within Melvin Butte and comparison to Whychus Watershed

Plant Association Group (PAG)			Comparison to Whychus watershed analysis
Name	Acres	% Acres	% Acres
Mixed Conifer Dry	2,123	40%	6.5%
Mixed Conifer Wet	1,571	29%	10.0%
Ponderosa Pine (Wet and Dry)	1,123	21%	1.4%
Lodgepole Pine	531	10%	3.2%
Mountain Hemlock Dry	8	<1%	<0.1%
Non-forest (Meadow)	18	<1%	1.3%
Non-forest (Cinder, Rock, Water)	2	<1%	<0.0%

Figure 3. Plant Association Groups located in the Melvin Butte Project Area.

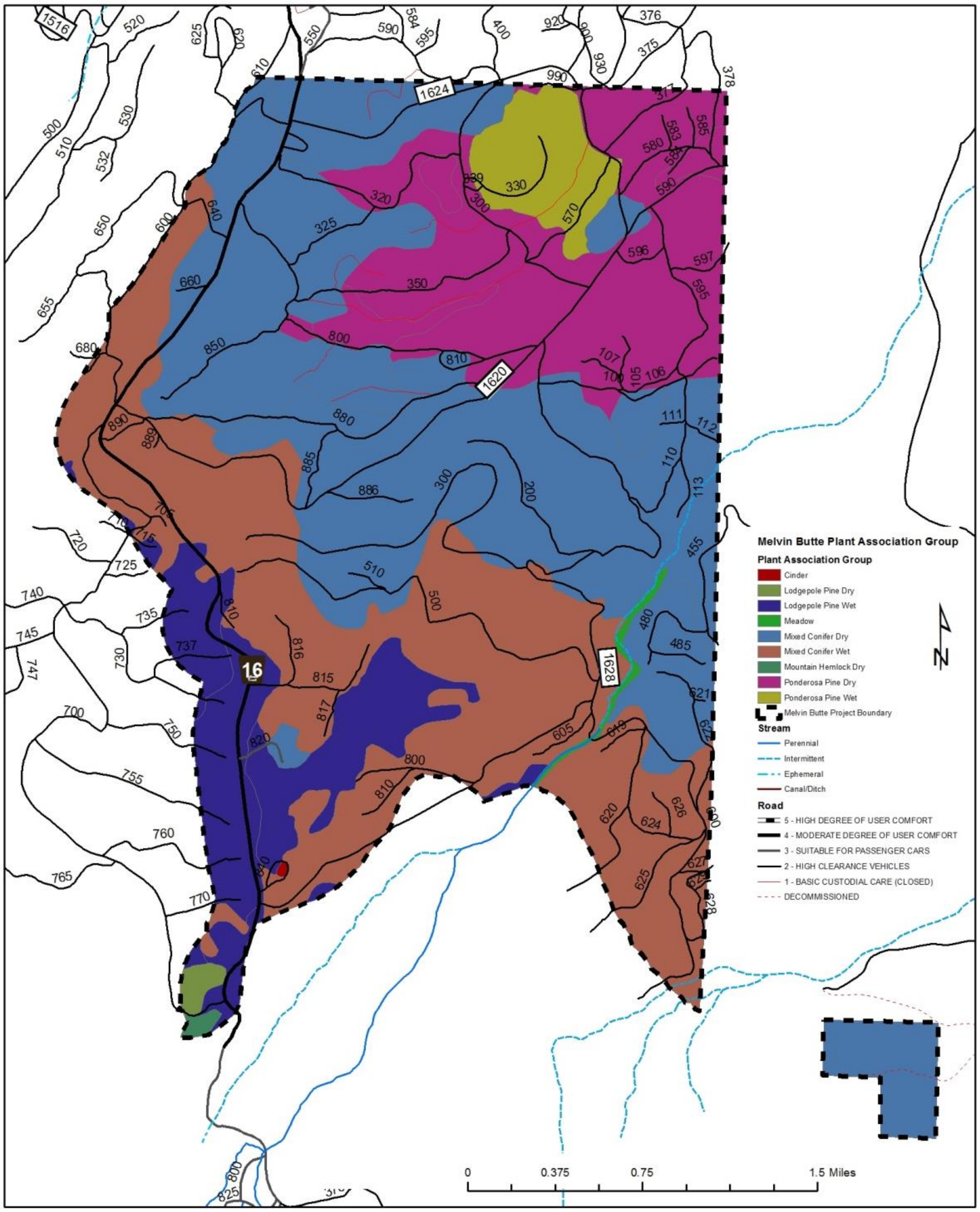


Figure 4. Mixed conifer stand indicating ingrowth of under- and midstory grand/white fir canopy layers.

Influences of Disturbance on Forest Vegetation

Disturbances contribute to ecosystem resilience and are an important process in continuing the cycle of forest renewal. Disturbances are a “double-edged sword” in that they can be both positive and negative on forest ecosystems processes and therefore affect resistance and resiliency. Disturbances in central Oregon include but are not limited to; fire, insects, disease and wind. These biotic and abiotic elements interact on the forest to influence size, severity, intensity and patterns of disturbances and thus relate to the sustainability of forest vegetation cover over the long-term. Generally, disturbance severity increases when forest conditions are outside the historic range of variability.

Mortality from disturbances is desirable, particularly in providing roosting, nesting, foraging and hiding cover for species that are directly or indirectly associated with snags (Bull et al. 1997). However, there have been alterations in the scale of mortality inducing disturbances, and potential thereof, that are currently affecting this watershed, other adjacent watersheds and more specifically, the Melvin Butte planning area (USDA 2013).

The greater primary historic disturbance in the project area was frequent, low to mixed severity fire, which helped maintain lower stand densities that maintained higher canopy base heights. Due to intrinsic species adaptations, this process contributed to stable ecosystem functions that promoted old growth development of fire resistant ponderosa pine (USDA 2013). Other important historic disturbance agents in the project area included mountain pine beetle, western pine beetle, and western dwarf mistletoe. In general, historical disturbances in the watershed and within the Melvin Butte project area caused mortality in single trees, small groups of trees, and less frequently, larger patches (ex. lodgepole PAG). These disturbances created fine-to mid-scale structural elements of diseased, dead, damaged and down trees. Many local species (wildlife, plant, insect, fungi, microorganisms, etc.) evolved with these historic disturbance cycles (Stine et al. 2014).

Currently, the primary types of disturbances on the Sisters Ranger District are uncharacteristically large, and moderately to highly severe wildfires, and larger scale insect and disease infestations (USDA 2013). These changes result in habitat condition fluctuations more extreme than historically experienced with potential loss of important habitat elements of larger old trees, canopy cover, large snags and down wood (Graham et al. 1999, Hessburg and Agee 2003, Hessburg et al. 2005, Hessburg et al. 2007). In addition, there may be a trend of slower recovery of the system, partly due to the effect of high intensity wildfires on soil productivity, invasive species, tree regeneration success and warming and drying trends (Littel et al. 2010, Spies et al. 2010, see Climate Change Report). The result is a greater impact on interior forest species which depend on the continuity of forested habitat (see Wildlife Report).

The scale of severe impacts from current and future disturbances can be reduced by maintaining and enhancing more resistant species (i.e., ponderosa pine), increasing the distribution of single or two storied-stands, reducing fuel continuity, improving or maintaining vigor, and making treatment units as large as possible (Wickman 1992, Peterson et al. 2005).

Structural and Seral Stages

Both structural and seral stage information provides broad-based canopy layer information for determining forested conditions within an area. Frequently, these are used to identify habitat suitability of different interior forest species (avian, mammalian, botanical, etc.); fire hazard; insect and disease susceptibility; and inference to historic range of variability.

Structural stage information provides vertical and horizontal canopy information among tree layers while seral stage provides information about specific species occupying those canopies. Both interact on the landscape based on past, present and future influences (planned and unplanned).

Past management (planned and unplanned) has altered the historic proportion of structural stages within the project area in two general ways 1) by allowing fire suppression/ exclusion to favor in-growth and 2) the regeneration harvests (plantations) creating a younger (stand initiation, (Oliver and Larson 1996)) stage of development[6].

More than 75% of the project area consists of areas dominated with less than trees < 20”dbh (Figure 3). Much of this acreage occurs as small blocks of plantations; second growth stands; regenerated stands from wildfire; lodgepole stands; or other areas dominated by small trees. Approximately 22% of the project area is composed of plantations (installed from 1981-1993) installed to reduce or remove the abundant mistletoe in the area (Big Buck, Black Pine, Walla Bear and Melvin Butte Timber Sales). Within portions of the lodgepole PAG, structural stages have been altered by the recent past beetle outbreaks and Pole Creek fire 2012.

A study looking at historical structure and composition of ponderosa pine and mixed conifer forests in south-central Oregon stated stand densities have more than tripled over the past 90 years in these sites,

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[6] Past selective logging was not listed here since structural changes have been offset by the time since logging and ingrowth of large grand/white fir into the mid/ overstory layers. Under similar growing conditions grand/white fir are well recognized for growing at faster rates than ponderosa pine (Simpson 2007).

while basal area has declined by greater than 50% and the abundance of large trees as a proportion of the total number of trees has decreased by more than a factor of five (Hagmann et.al. 2013).

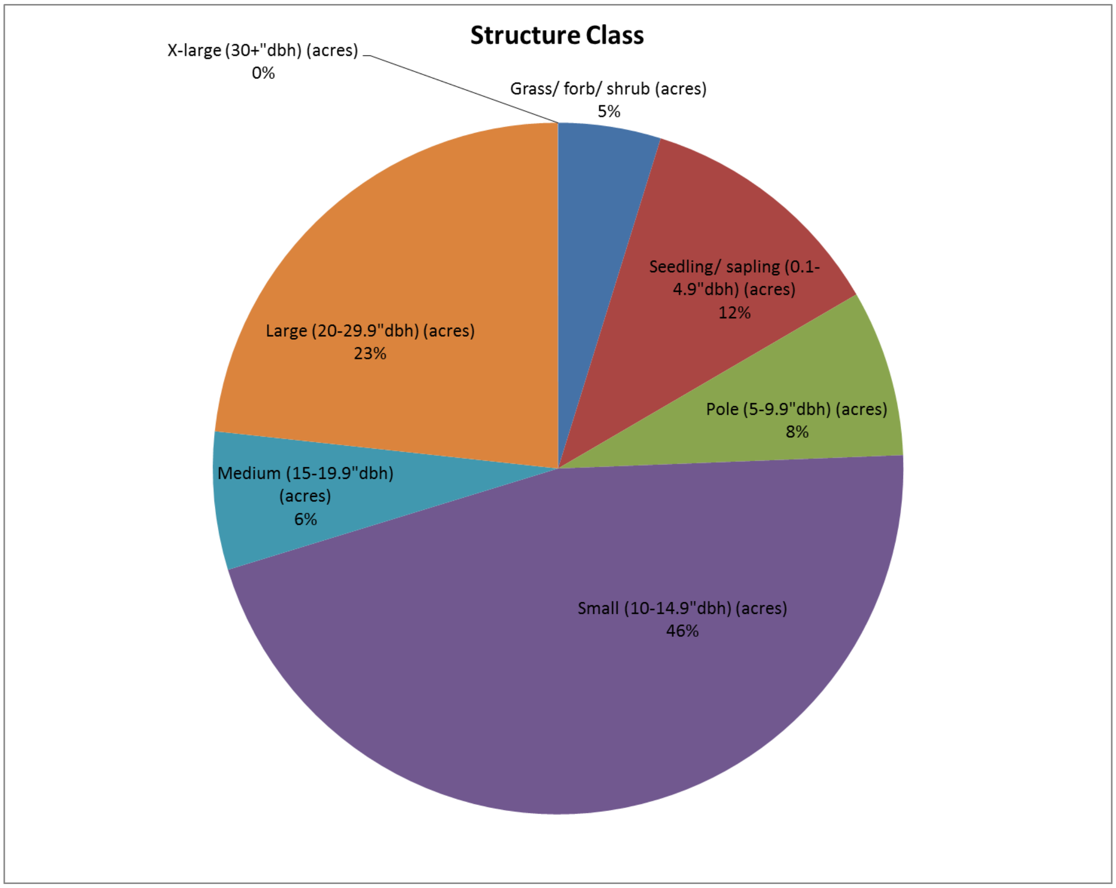

Figure 5. Structure classes of Melvin Butte as determined by Lidar.

Past management (planned and unplanned) has altered seral stage in two general ways 1) by interrupting fire regimes allowing ingrowth of grand/white fir (succession process) 2) by selective logging[7] of overstory ponderosa pine and altering species proportion (assumed more ponderosa pine = more pine seed mast).

Tree Species Composition

Major conifer trees species in the project area include ponderosa pine, grand/white fir, lodgepole pine and western juniper. Other species that are present but comprise <0.001% of all trees include Engelmann spruce, mountain hemlock, pacific silver fir, and white bark pine. These minor species occur as individuals very sporadically at >5000ft elevation. Douglas-fir may be present, but not a single

[7] Selective logging changed the proportion of overstory pine about 30-60 years ago in much of the Melvin Butte project area.

observation was noted within the planning area (managed and unmanaged stands). Douglas fir may be present within the Three Creek drainage, but restoration work is excluded from riparian reserve areas.

Approximately 90% of the project area is composed of plant associations groups (PAGs) dominated by ponderosa pine which includes mixed conifer plant associations dominated by ponderosa pine during historic fire regimes (Volland 1985, Simpson 2007, Franklin 2013, Hagmann et al. 2014). Low-density and pine-dominated forests historically occupied essentially all of the forested landscape within the ponderosa pine and mixed conifer sites of the eastern slopes of the Cascade Mountains (Herschel et al. 2014, Hagmann et.al. 2013, Hagmann et al. 2014).

Species Composition Changes

The most dramatic changes in species composition (proportions) have occurred in the mixed conifer (dry and wet) plant association stands that have had selective overstory removal and fire suppression/exclusion (Camp 1999, Franklin 2013, Merschel 2012, Merschel et al. 2014). These two mechanisms have interacted to advance grand/white fir persistence and abundance. In these stands, the trees per acre of ponderosa pine have decreased while grand/white fir has increased. In the mixed conifer types, the interactions of the two former conditions have resulted in dramatic pine to grand/white fir species shift when compared to reference conditions (Merschel et al. 2014, Hagmann et.al. 2013, Hagmann et al. 2014). As a result, the grand/white fir series in the project area (outside of plantations) has affectively had accelerated succession (increases of grand/white fir) due to these planned and unplanned management activities. In areas that have had their entire overstory removed (plantations in any PAG) follow up reforestation activities largely included ponderosa pine. As a result plantation stands have a significant cohort of fire adapted ponderosa pine and at this time are not threatened from grand/white fir stand succession.

Stand Density

Different biophysical environments can support different levels of tree densities (e.g. wetter, richer soils tend to be able to support more trees per acre). Tree growth, insect and disease resistance, fire behavior, habitat, snag recruitment and more are all affected by tree densities. Stand density is a primary factor affecting growth and vigor of forest vegetation, and resilience to disturbances. Measuring stand density provides forest managers information about what can be expected to forested conditions in the face of planned or unplanned events/actions (Figure 6, 7).

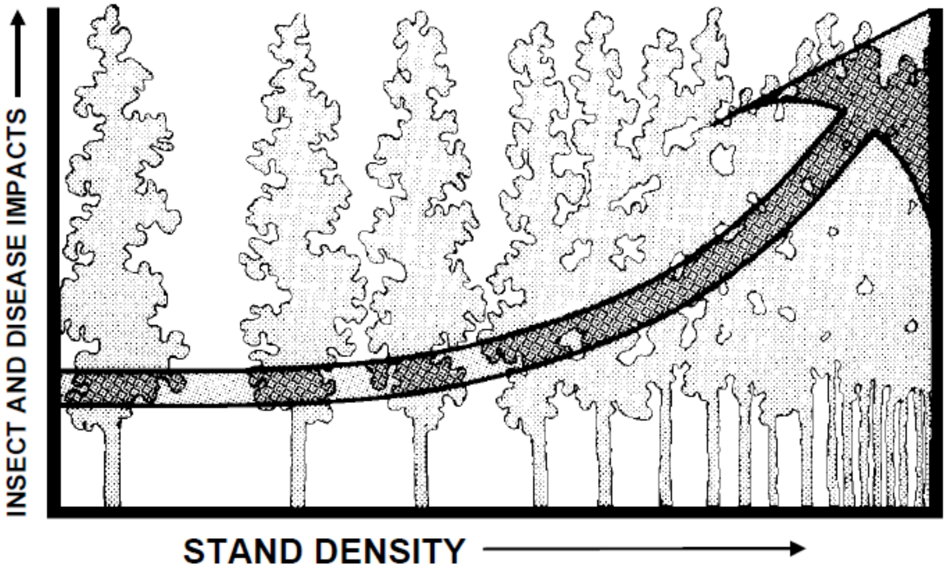

Figure 6. Insect and disease impacts can vary with stand density (from Powell 1994). Because open stands generally have higher vigor levels than dense stands, they tend to be more resistant to insect and disease impacts. Maintaining a wide stand spacing results in a condition where the trees are not experiencing significant competition. Although not universally true, vigorous trees are better able to withstand attack from insects, pathogens and parasites (Safranyik and others 1998).

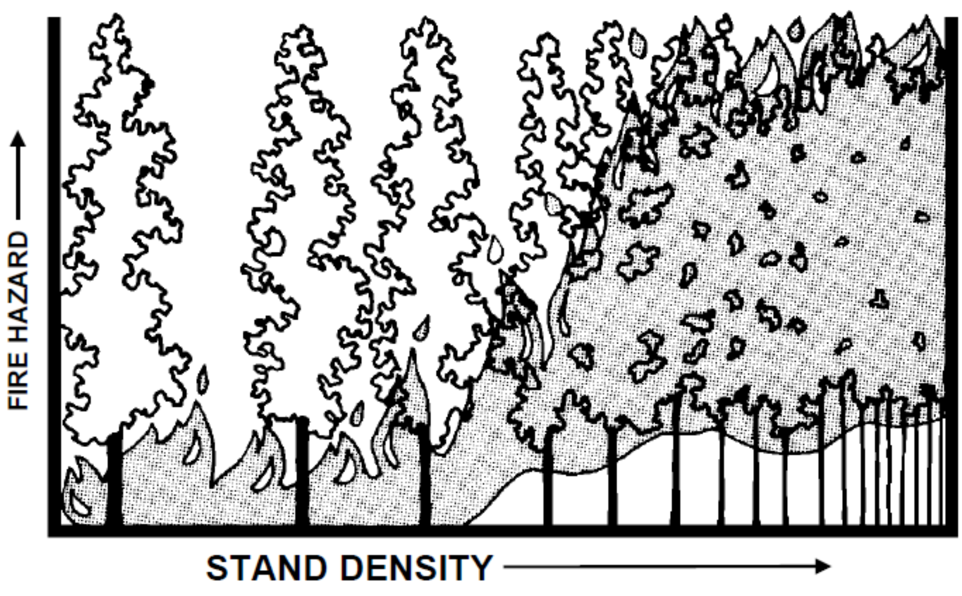

Figure 7. Fire intensity can vary with stand density (from Powell 1994). When a fire moves through an open stand with widely-spaced trees, it generally stays on the ground as a low-intensity burn. But when it encounters a dense, closely-spaced stand, fire is much more likely to leave the ground and begin moving through the intermingled tree crowns as a lethal, high-severity burn.

Stand density index (SDI) is a measure of density and provides as an indice of forest health concerns including and not limited to; competition, fire hazard, habitat hang-time, beetles and diseases (Reineke

1933, Cochran et al.1994, Powell 1999, Jain et al. 2002, Powell 2010, Franklin et al. 2013). SDI is broken up into “zones” to assess relative growth and inter-tree competition. Full stocking (also called normal) is a zone where tree vigor is slowed to the point where trees are self-thinning and have an increased likelihood of mortality agents. This onset induces stand differentiation and facilitates structural stage alterations (Oliver and Larson 1996). Below full stocking, are the lower and upper management zones (LMZ and UMZ) where partial to full competition occurs and inter-tree competition and mortality agents are less likely. To add, different tree species respond differentially to inter-tree competition and, as such, different SDI values are calculated (Cochran 1994, Powell 1999). Managing for species with lowest SDI values on a site ensures all other trees species are accounted for. Ponderosa pine is more sensitive to high stand densities than other tree species in the project area. The longer a ponderosa pine remains in overcrowded conditions, the less it is likely to reach 21” or greater diameter. Stump analysis on the Sisters Ranger District revealed that large ponderosa pine trees initially had rapid growth rates (due to little competition) for the first 50 to 100 years and less growth over time as density increased and trees aged.

The upper management zone is a site-specific density threshold, above which forest health conditions and large tree health are likely to deteriorate. When these limits are reached, plant competition results in loss of plant growth and/or mortality. Increased tree stress reduces tree vigor and the ability to resist insects and disease. Reduced tree vigor also decreases the tree’s ability to compartmentalize fire damage and recover from lost foliage, cambium damage and bud loss. Different parts of the project area can support different stand densities, depending, in part, on available water, light and nutrients. As such, it is necessary to adjust SDI maximum values for the particular biophysical location to better optimize growth and predictions (Figure 2).

With forecasted climate change, drought conditions are expected to become more common which in turn is expected to create favorable mortality conditions in the old, large trees (Spies et al. 2010, Little et al. 2010).

Old Growth Structure and Stand Density: All growing sites have a fixed quantity of resources and growing space, and as inter-tree competition increases it is usually the large trees that die first (Dolph et.al. 1995, Fitzgerald et.al. 2000).

Current mortality across the Melvin Butte Project area is generally occurring as individuals and groups of trees. Of particular importance, the largest proportion of mortality is occurring from large and old ponderosa pines and is due to effects of inter-tree competition (density), bark beetles and western dwarf mistletoe. Large old trees are the key structural component of old-growth forests both for their habitat functions as living trees, and because they contribute to the large snag and down wood component of these forests. In most cases these trees occur amongst an under- and midstory of ponderosa pine and grand/white fir (Figure 4). Under current conditions these high value trees[8] are declining, and will eventually become rare with replacement delayed (Eglitis et al. 2015).

Recent studies have shown that ability of old growth trees to respond to reductions in density from thinning treatments, indicating an improvement in tree vigor and increased resistance to insects and

[8] Numerous publications and Deschutes County Forest Collaborative group meetings have identified old growth ponderosa pine as both a social and ecological value. See Franklin et al. 2013.

pathogens (McDowell et al. 2003). Latham and Tappeiner (2002) measured diameter growth increments of old-growth ponderosa pine, Douglas-fir, and sugar pine in the southern Cascades of SW Oregon. Ponderosa pine basal area growth was significantly greater in the treated stands than in the control stands. Fitzgerald and colleagues (2000) are testing the hypothesis that managed old-growth stands, where density and composition are maintained at historic levels, remain viable longer as old-growth habitat (Genesis Research and Demonstration Area). Stands were treated with thinning followed by underburning. Preliminary results, after 3 years of measurement, indicate that vigor of residual old-growth trees is increasing. A similar study has been initiated in the Whitehorse area of the Lolo National Forest (Hillis, et.al. 2001). The authors anticipate increased growth response of the residual old-growth trees, based on nearby research showing response of 800 year old pine to release from competition by fire. Based on this research, it is assumed that reducing stand densities would help maintain existing large trees, and provide better conditions for the growth of future large trees.

Table 5. Stand density by PAG

PAG	Avg. BA weighted DBH (inches)	Avg. Tree per acre	Avg. BA per acre	Avg. SDI	%MaxSDI	Acres
Ponderosa pine	15.7	856	149	336	88	1123
Mixed conifer	15.5	1697	207	499	74	3693
Lodgepole	14.3	1804	208	500	77	531

Table 6. Stand density by structure

Structure	Avg. BA weighted DBH (inches)	Avg. Tree per acre	Avg. BA per acre	Avg. SDI	%MaxSDI	Acres
Plantations (pole sized)	7.2	752	125	444	75	1174
Medium to large trees areas (including old growth)	15.9	1633	209	499	82	2509

Reducing forest densities, simplifying stand structure and reducing fuels to resemble conditions within the natural or historic range of variability is expected to reduce the risk of severe stand-replacing wildfires and widespread insect and disease outbreaks, as well as reduce the intensity of effects when disturbances occur. Forest conditions comparable to those found in historical records, such as the timber cruise from the Warm Springs Reservation, have demonstrated that open, low density stand conditions promoted resilience and resistance to fire and drought related stressors (Hagmann et.al. 2014). Reducing stand densities could also help maintain old-growth ponderosa pine longer on the landscape by reducing competition stressors. The Whychus Watershed Assessment (USDA 2013) states “maintaining stand densities at manageable levels is essential for promoting forest health and maintaining or creating large tree character and habitat in dry areas (pg. 58).

Fire

Fire was historically the most influential disturbance agent in forests east of the Cascade Crest, with low- to mid-elevation sites dominated by a frequent/low-severity fire regime (Hessburg et al. 2005, Hessburg et al. 2007). Frequent fires in ponderosa pine maintained surface fuels at fairly low levels, kept understory vegetation and tree densities low and at low heights, preventing the formation of ladder fuels that could carry fire into the upper canopy. However, fire regimes in the dry forests have undergone a dramatic change to a less frequent and higher severities (Everett et al. 2000). Hessburg et al. (2005) estimated that the area in the Columbia Basin with potential for low severity fire has decreased by 53 percent, while the area with potential for high severity fire has doubled.

Fire suppression/exclusion and selective logging of large, fire-resistant trees has led to the condition where high-severity fire is now common in forests such as these (Merschel 2012, Merschel et al. 2014, Stine 2014, USDA 2013). Alteration of disturbance processes has resulted in increased fuel loadings and connectivity (both vertically and horizontally), and increased susceptibility to insects and disease (Hessburg et al. 2005).

Fire suppression/exclusion has allowed the establishment and dominance of grand/white fir in the dry grand/white fir series, where ponderosa pine was historically maintained as the dominant species by frequent low to mixed severity fires. The stands originating after partial overstory removal cutting are dominated by grand/white fir due to lack of a remaining pine seed source and altered fire regimes. This has had the effect of perpetuating the dominance of this late seral species (Merschel et al. 2014).

The historical fire regime for the ponderosa pine and dry mixed conifer series was frequent, low severity surface fires (broad- and mid-scale) (Franklin et al. 2013, Stine et al. 2014). Studies have shown that fire return intervals were very short pre-settlement and were dominated by large ponderosa pine (Everett et.al. 2000, Hessburg et al. 2005, Hagmann et al. 2014, Merschel et al. 2014, Stine et al. 2014). On a fine-scale, however, individual and group tree torching diversified stand structure into mosaic and allowed for recruitment of snags. The high live crowns and thick bark of mature trees protected them from the low-intensity wildfires common in the ponderosa pine and dry mixed conifer types. The frequent low-severity fire regime of ponderosa pine led to the most stable[9] landscape pattern of all the eastside forest vegetation types. These predominant surface fires maintained low and variable tree densities, light and patchy ground fuels, simplified broad-scale forest structure, favored fire-tolerant trees, such as ponderosa pine, and a low and patchy cover of associated fire-tolerant shrubs and herbs (Hessburg et.al. 2005). The historic landscape pattern in ponderosa/ dry mixed conifer was uneven-aged at the landscape scale but even-aged at the stand or group scale, resulting in a landscape of open park-like stands of trees with the understory dominated by herbaceous vegetation. The even-aged patches within the landscape pattern were created when individual trees or small groups of trees died, creating gaps in which new even-aged clumps could develop.

Relative to pine/ dry mixed conifer forests, mesic forest types exhibited a wider range in fire severities with a larger area burned at mixed to high severities (Wright et.al. 2004, Hagmann et al. 2014, Stine et al. 2014). High severity fire effects were documented in historic timber cruise data at the upper elevation

[9] Stable here referring to consistent high proportion of ponderosa pine/time

boundary of moist mixed conifer habitat adjacent to colder, wetter habitat types (Hagmann et.al. 2014). Lower elevation mixed conifer sites where historically dominated by ponderosa pine and experienced lower severity, frequent fire (Merschel et al. 2014, Hagmann et.al. 2014).

Lodgepole pine has a longer fire return interval with higher severity fires resulting in more stand replacement. The historic landscape pattern in the lodgepole pine type was even-aged with large patches of even-aged stands of lodgepole pine regenerating after a stand replacing disturbance event, such as fire or a bark beetle outbreak.

Fire Regimes

Fire regimes have been identified for all plant associations occurring across the Deschutes National Forest (Volland 1988, Simpson 2007). Fire regimes are influenced by biotic and abiotic conditions including; stand conditions, fuels, weather. See Fire and Fuels report for more information on fire regimes.

Fire Hazard

Fire hazard is defined by the fuel complex, as determined by the volume, type, condition, arrangement, and location which determine the ease of ignition and resistance to control. Fire hazard expresses the potential fire behavior for a fuel type, regardless of its weather-influenced fuel moisture content (Hardy 2005). Fire hazard is discussed below in terms of the fuel profile and potential fire behavior. The Fire and Fuels Report includes additional information on fire hazard.

Fuels

Surface Fuels

Estimates of surface fuel loadings are based on existing fuels information taken during stand exams and inputted into the FVS-FFE model. Surface fuels in the project area consist mainly of shrubs (i.e. green leaf manzanita, bitterbrush), litter and duff, down logs, branches and twigs. The shrub component is variable but where it is present tends to form a continuous component of the fuel bed. Surface fuel loadings are presented in Table 8.

Table 7. Surface fuel loadings (tons/acre) and predicted flame lengths (ft.) for PAG

PAG	Acres	Avg. Surface fuel loading Total	Avg. Surface Flame Severe
Ponderosa pine	1123	17	5
Mixed conifer (dry and wet combined)	3693	21	5
Lodgepole[10]	531	22	6

Canopy Fuels

Canopy base height (CBH) is the lowest height above the ground where there is sufficient amount of canopy fuel to transition a fire from the surface fuels into the tree crowns (Scott and Reinhardt 2001), and

[10] Much of the lodgepole PAG has experienced a widespread beetle epidemic and/or Pole Creek Fire 2012. This material has and continues to fall down creating jack-strawed fuels near the 16rd.

canopy base heights are a critical factor in determining crown fire potential due to the effect of understory trees carrying fire into tree crowns via torching. Canopy base heights were determined for the project area from the Forest Vegetation Simulator (FVS-FFE) using stand exam data. The structure and species composition of the stands, with dominance by grand/white fir with low growing crowns, as well as dense understory trees, and the numerous plantations are contributing to the low canopy base heights observed (Table 6). CBH should be considerably higher than the height of expected flame lengths (Table 5) in order to avoid torching and potential crown fire initiation. The fuels continuity from the surface fuels to the crown fuels, as indicated by the CBH values in Table 4, has created the potential for surface fire to reach the crowns of the overstory trees.

Canopy bulk density (CBD) is the mass of available fuel in the form of needles, branches and twigs per unit of canopy volume (kg/m3), and is an important characteristic needed to predict crown fire potential and spread. Canopy bulk densities were estimated from FVS-FFE within the project area (Table 4). CBD affects the critical spread rate needed to sustain active crown fire. The lower the canopy bulk density, the lower the potential for active crown fire. The threshold CBD for reducing the likelihood of active crown fire depends on fire weather and rate of spread and is not well defined, but may be less than 0.10 kg/m3 (Agee 1996, Peterson et al. 2005). Across PAGs and structure types, CBD is currently above this threshold or is approaching it (Tables 9, 10).

Table 8. Fire metrics related to canopy fuels by PAG

PAG	Acres	Avg. CC %	Avg. CBH (ft.)	Avg. CBD (kg/m^3)	Avg. % Mortality BA- Severe Fire	Avg. Crowning Index (mph)
Ponderosa pine	1123	56	6	0.09	45	27
Mixed conifer	3693	63	5	0.17	75	18
Lodgepole	531	25	5	0.20	83	15

Table 9. Fire metrics related to stand structures

Structure	Acres	Avg. CC %	Avg. CBH (ft.)	Avg. CBD (kg/m^3)	Avg. % Mortality BA- Severe Fire	Avg. Crowning Index (mph)
Plantations (pole sized)	1174	62	5	0.16	69	19
Medium to large trees areas	1507	60	5	0.11	49	26

Flame Lengths/ Crown Fire Potential

Surface flame lengths are a measure of how intense or severe a fire may become and a proxy for ease of fire suppression (resistance to control). Heavy surface fuel loads generally contribute to longer flame lengths. Since surface fuels consists mainly of shrubs, grass/sedge and duff, and scattered larger dead and down material, predicted average flame lengths are generally 5 feet across the project area. Canopy base height across the project area is generally also at this height (5ft) (Tables 8, 9, 10). The interaction of these two and severe fire weather are factors that have the potential to lead to crown fires and/or lethal surface fires that could kill a large proportion of the forest in the project area.

Crown fire potential, or hazard, is based on the amount of surface fuels, the amount of ladder fuels, and the density and spacing of the canopy. Heavy surface fuels generally contribute to longer flame lengths. Low canopy base heights can carry surface fires into the crowns. Once established the crown fire may persist. The more spaced the canopy, the greater the wind necessary to move fire from one crown to the next. Dense canopies require much less wind speed to support crown fire. The crowning index integrates these factors into a single value that reflects the hazard of crown fire being initiated and sustained.

FFE-FVS uses information about surface fuel and stand structure to predict whether a fire is likely to crown. Crowning index is a measure of how susceptible a stand is to developing a crown fire when a fire occurs. It depends on canopy bulk density, slope steepness, and surface fuel moisture content. As a stand becomes denser, active crowning occurs at lower wind speeds, and the stand is more vulnerable to crown fire. Lower index numbers indicate that crown fire can be expected to occur at lower wind speeds, so crown fire hazard is greater at lower index values. Current values for crowning index (wind speeds in miles per hour) in the project area are at or above the expected potential 14 mph wind speed for a fire in this area, indicating that the project area is moderate to highly susceptible to crown fires (see Table 6,7). In addition, wind gusts must also be taken into consideration, and given the low CBH tree torching is likely to occur and could be sustained over with higher wind speeds. Overall, the crowning index values in Table 8 and 9 likely represent a moderate to high hazard of crown fire (see Fuels report for more information).

Crown fires are typically faster moving than surface fires, and result in more tree mortality and smoke production. A crown fire would loft more firebrands into the air than a surface fire due to the amount and type of fuel being consumed. A crown fire is generally more intense, thus producing more wind and convective heating. These forces acting alone or in combination would carry firebrands greater distances and increase likelihood for spotting to other areas. Crown fires are more dangerous than surface fires and are more difficult to suppress.

Predicted Fire Type and Severity

FVS-FFE was used to predict the type of fire and amount of mortality from a wildfire burning under severe (90th percentile) weather and fuel conditions. Four types of fire are recognized by the model, 1) surface fire which does not burn in the tree crowns, 2) active crown fire where the fire moves through the tree crowns killing all trees, 3) passive crown fire where individual trees or groups of trees are killed as their crowns torch, and 4) conditional crown fire where surface fuels are not heavy enough to sustain a crown fire but canopy bulk density is great enough that crown fire could be initiated from a neighboring stand. Predicted mortality is based on the amount of crowning, scorch height, species, and bark thickness.

The type of fire resulting from an ignition under severe conditions in the project area would be a combination of active, surface, passive and crown conditional fire (Table 8). Mortality is predicted to average 72 percent of the basal area. Much of this mortality would likely be from the combination of fire types associated with the different structures and ease of spread from ladder fuels and dwarf mistletoe. Of particular importance is the large overstory ponderosa pine mortality susceptibility from ladders and root damage from buildup of bark mounds at the base of trees over time.

Table 10. Predicted fire type, severity and proportion of Melvin Butte Project area

Predicted fire type and severity	Proportion of project area (%)
Active	22
Passive	12
Crown Conditional	27

Surface	39

Based on experience with previous wildfires, namely the Pole Creek Fire of 2012, fire behavior is expected to have moderate to severe effects on tree survival, and fire modeling with FVS-FFE substantiates this assumption. Passive or active crown fire is likely to occur wherever there are substantial amounts of understory trees that could bring fire into tree crowns, and higher wind gusts could lead to active crown fire as well. Soil heating and root damage is also likely to occur around heavier buildup of down woody fuels, leading to direct and indirect (insects/disease) mortality from fire.

Insects and Disease

The roles of insects and disease as disturbance agents in forests are very closely tied to vegetation patterns. Factors such as species composition, size structure, and density of forest stands are important in determining which agents are likely to affect that vegetation type. By their actions, forest insects and diseases can alter the vegetative patterns and set the stage for new processes to occur.

The primary mortality-inducing insects within the project area include western pine beetle, mountain pine beetle and pine engraver beetle (Eglitis et al. 2015). Mountain pine beetle are capable of causing extensive tree mortality and most often exhibit preference for larger diameter trees growing in high density stands with a high percentage of host type (Fettig et.al. 2007). When tree densities are above the upper management zone for density (see section on stand density for a definition of the upper management zone) they are considered imminently susceptible to bark beetles (Powell 1999, Eglitis et al. 2015). A study done in the Colorado Front Range illustrated that mountain pine beetle-infested plots exhibited higher basal area and stand density index (SDI) for ponderosa pine versus all tree species combined (Negron et.al. 2004). Bark beetles also tend to thin from above, killing the larger trees within the stand first. Within infested plots, infested trees were larger in diameter at breast height and in the dominant and co-dominant crown positions (Negron et.al. 2004).

Western Dwarf Mistletoe

The primary disease found in all size/ age classes of ponderosa pine throughout the Melvin Butte project area is western dwarf mistletoe (WDM). The level of infection is largely related to PAG (Table 18) and to the incidence of past regeneration harvesting and/or pruning that has occurred. In general in the ponderosa pine PAG, the past regeneration harvest units (plantations) show the lowest level of infections. However, about 2/3 of these plantations now indicate spread interior to their stands, undermining the original purpose (Figure 8).

It is believed that incidence of dwarf mistletoe is elevated from historical conditions within the project area. Frequent, low-intensity fire played a large role in moderating the presence of mistletoe by maintaining fewer trees in lower canopy layers that would become infected and spread seed as well as ‘pruning’ lower limbs with broom-like infections on the larger trees (Bolsinger 1978, Hessburg et al. 1994, Campbell and Liegel 1996, Hessburg et al. 2008). Severely infected trees were also more likely to torch resulting in individual tree or small group mortality. This created gaps where mistletoe spread between trees was less likely to occur.

Fire suppression/exclusion has caused increased infection in these stands by allowing susceptible understory trees to establish, become infected and increase the incidence and rate of spread higher than historical levels (Edmonds et al. 2000). Ponderosa pine infected with WDM exhibits increased mortality due to successful western and mountain pine beetle attack (Miller and Keen 1960; Eglitis et al. 2015); reduced volume and height growth (Hawksworth 1996, Maffei and Jacobi 1986); reduced viable seed production for natural regeneration (Hawksworth 1996); and increased susceptibility to mortality from fire (Conklin and Geils 2008). These effects are proportional to increasing levels of infection (see Appendix F). A stand heavily infected with dwarf mistletoe has a decreased likelihood of developing into old forest structure (Hopkins 1992, Eglitis et al. 2015). Outbreaks of mountain pine beetle may increase the proportion of infected trees by killing the uninfected trees and increasing the rate of spread of mistletoe. Thus, management objectives for both beetles and dwarf mistletoe need to be taken into account (Edmonds, Agee and Gara 2000).

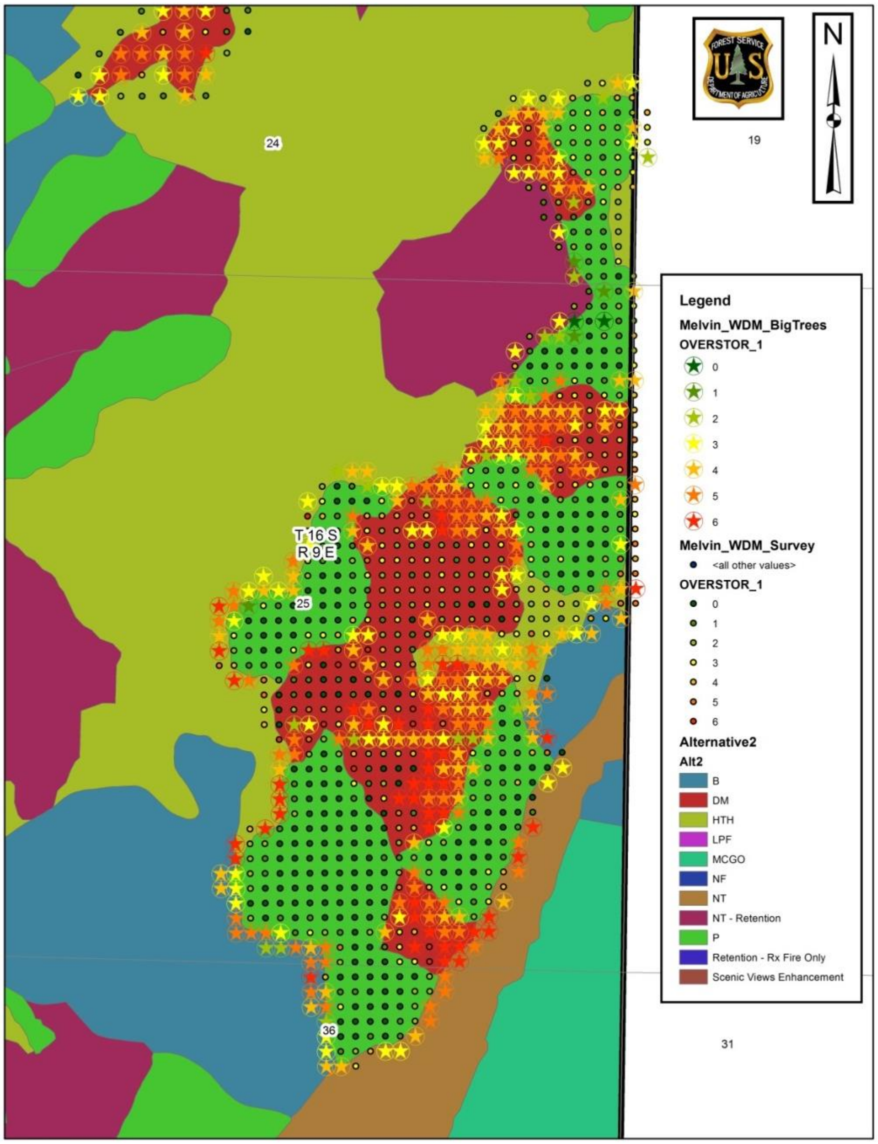

Figure 8. Western dwarf mistletoe ground survey of selected Melvin Butte stands (Hawksworth 1977). Green polygons represent plantations. Circled stars indicate >21”dbh ponderosa pine and small circles indicate ponderosa pine <21”dbh. Green circles and circled stars indicates no to light infection transitioning to red with severe infections.

Project Area Insect and Disease Review and Recommendations

The project area was visited by Forest Health Protection Staff Helen Maffei, Ph.D. (Area Plant Pathologist), Brent Oblinger (Area Plant Pathologist) and Andris Eglitis Ph.D. (Area Entomologist) at multiple times in summer 2014. The full reports for these visits can be found in the project record. Their conclusions and recommendations are summarized below:

Findings:

Western Dwarf Mistletoe:

Western Dwarf Mistletoe is a key disturbance agent influencing stand health and structure throughout parts of the project area. Severely infected trees (DMR 5 or 6; Hawksworth 1977) are adversely infected and when they occur within large old trees their persistence is shorter than those without mistletoe. Managing for trees (replacement) underneath infected overstory is dubious at best and typically unsuccessful. Infected ponderosa pine (esp. larger ones) in adjacent stands (or parts of the same stand) can be detrimental to the effectiveness of the treatment. Thinning treatments using unevenaged silvicultural tools is complex, requires fine-scale knowledge of infection levels and extent, often time requires follow up monitoring and is often unsuccessful.

Recommendation- Prioritize dwarf mistletoe areas based on fine-scale cues of infection level, location of infection and stand conditions.

Insects:

Western bark beetle is the most significant beetle in the project area with scatter small pockets of ponderosa pine dead and dying. Mountain pine beetle is also present in small quantities attacking ponderosa pine and those pine weakened by western dwarf mistletoe and other areas under high stem densities. Western dwarf mistletoe is causing ponderosa pine to be more susceptible to the various pine bark beetles in the area. Adjacent and recent wildfires may contribute to population buildups of bark beetles. Legacy ponderosa pine are under extreme competition with grand/white fir throughout the understory and cannot compete successfully in the long term. White fir within the dry plant associations are not sustainable in the long-term especially at or below 20” of annual precipitation.

Recommendation- Thinning for density reduction using “management zone” as an indicator is an important predictor for likelihood of insect/ disease susceptibility (Cochran 1992, 1994).

Past Vegetation Management Activities

Vegetation management activities in the Melvin Butte project area have included timber harvest, small tree thinning, firewood cutting and prescribed fire. Table 5 summarizes the known past management activities.

Table 11. Known past management activities within the Melvin Butte Project Area.

Ownership at the time of the Treatment	Management Activity	Approximate Acres
Public (Forest Service)	Overstory Removal	177
Public (Forest Service)	Regeneration Harvest	944
Public (Forest Service)	Harvest Partial Removal	261
Public (Forest Service)	Selection Harvest	590
Public (Forest Service)	Thinning	261
Public (Forest Service)	Timber Stand Improvement	1,044

Desired Future Condition

On a broad-scale, development of the desired future condition comes, in part, from the 1998 Whychus Creek Watershed analysis which outlined watershed conditions from a 178,161 acre scale. Numerous changes have occurred since this analysis resulting in renewed attention in addressing forest health issues in some of the last continuously forest acres within the watershed.

Large-scale high severity (stand replacement) fires (>10 acres) and a mountain pine beetle outbreak (>10 acres) have altered the surrounding landscape. Resultant vegetation condition changes prioritized a 2009 watershed analysis (for Popper Project area[11]) and finally a 2013 (post Pole Creek Fore 2012 and pre this analysis). This condition change recognizes an urgent need to address forest conditions that have the potential to threaten interior habitat loss and resiliency in the face of uncertainty. The project boundary encompasses Strategy Areas 1, 2, and 4 and are listed as "urgent" to "moderate".

A healthy, diverse, fire-resilient forest structure can be restored in these forest types through restoration treatments that include reducing stand densities, fuel loads and western dwarf mistletoe abundance and altering late seral species proportions. Maintaining stand densities at manageable levels is essential for; promoting forest health; maintaining or creating large tree character habitats; and meeting the goals of the Whychus Watershed Analysis.

Forest health is an important consideration in the management of stands within the Melvin Butte (see Insects/Disease, above).

The Forest Service Forest Health Protection staff defines forest health as, "A condition wherein a forest has the capacity across the landscape for renewal, for recovery from a wide range of disturbances, and for retention of its ecological resiliency while meeting current and future needs of people for desired levels of values, uses, products, and services" (Twery and Gottschalk, 1996). Treatment strategies to enhance forest resilience and wildlife habitat, and to affect potential fire behavior by allowing forests to equilibrate to fire under modern conditions, and for increasing forest heterogeneity are outlined in several recent publications (Franklin et al. 2008, North et al. 2009, Franklin et al. 2013).

Desired Future Condition for Forest Vegetation

Desired future condition includes maintaining and improving habitat for interior forest species, reducing fire hazard, maintaining and enhancing a heterogeneous landscape with stand densities and species composition that favor resistance and resiliency to future unknown disturbances. The Melvin Butte project area contains different PAGs and as such desired future conditions are modified, by these PAGs to capture broad-scale variations.

Overview

A forest with medium to large ponderosa pine acting as "anchor" points to continuous forest cover over the long-term; a condition indicative of Pre-European settlement (100-300 years past). A variety of stand conditions would be distributed throughout this larger ponderosa pine tree matrix. Stand densities, species composition and fuel loads would be consistent with natural fire frequencies. Snag and down log levels would be consistent with historic levels. The forest would be resistant and resilient to fire, insects, diseases and other future unknown disturbances.

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[11] Popper Project area was planned, had public collaboration (Deschutes County Forest Project), and was nearing Decision when on September 9th, 2012 a wildfire began in the project area (Pole Creek Fire Assessment 2012).

The sustainability of this condition is an important characteristic. In this desired condition, there is a balance of various vegetation conditions so that although portions might not be perfectly resistant to large-scale fire, or insect/disease outbreaks, etc., yet on the whole, the landscape would exhibit resilience, so that when these natural disturbances occur it recovers more rapidly, without entire loss of broad-scale resource values.

Ponderosa Pine

The ponderosa pine plant association is made-up of relatively open stands of ponderosa pine that have irregular distribution both as individual trees and as relatively small groups. Reproduction is often in even-aged patches up to several acres in size, and scattered grass/shrub/forb openings, 1/10 to ¼ acre in size with a few larger scattered trees. This plant association group will generally develop into a ponderosa pine climax condition, with infrequent denser stands found in riparian bottomlands and other moist ecotones. Stands are primarily one or two storied and are often less than 25% canopy closure. Understories are almost entirely ponderosa pine as scattered individuals or small ($1/10^{th}$-$1/4^{th}$ acre) even-aged groups. Shrubs and grasses are young and vigorous, reflecting the influence of frequent, low intensity fire. Low intensity fire is the primary disturbance agent, with fire return intervals ranging from 5 to 20 years.

Mixed Conifer (Dry and Wet)

The mixed conifer landscape is a mosaic of varying patch sizes and seral stages and formed from influences of adjacent areas, site productivity and disturbance regimes. Stands contain a range of small, medium and large trees. Ponderosa pine is the dominant overstory "anchor" species with sparse understories of both shade tolerant and intolerant species. Low to mixed intensity fire return intervals are 0-50 years and help maintain seral species and prevent the dominance of climax species in most stands. Snag and down log levels would be consistent with historic levels and standards in the Northwest Forest Plan. Fire severities within mixed conifer PAGs would encompass the range from low to high severities with high severity consisting < 10% of the burn area occurring as small patches distributed throughout the burn area (departure from Watershed Analysis). In wet mixed conifer, stand replacement effects were more widespread in patches than surface fire effects, while in dry mixed conifer, surface fire effects are more widespread by nearly 2:1 (Hessburg et.al. 2007). Scattered stands of climatic climax conditions exist where disturbance intervals are longer. These stands are generally older, have higher site productivities and have a higher density of the largest trees.

Mixed Conifer Dry – Generally these areas are one or two storied stands with 20% to 40% canopy closure. Understory trees and shrubs are unevenly distributed and a mix of shade tolerant and intolerant species. Grand/white fir does not comprise more than 20% of the stand. Snags present are sufficient to meet 100% MPP for wildlife focal species (usually 4 to 7 per acre). Down logs are scattered throughout the stand. Small openings exist, generally less than 10 acres in size, with 10 to 15 trees per acre (primarily ponderosa pine) and with large snags present/created.

Mixed Conifer Wet – These plant associations occur mostly in moister ecotones such as riparian bottoms, higher elevations, north slopes, or other areas with fire return intervals at the upper end of 0-50 years.

These stands are multi-storied, with 30%-60% canopy closure, and include a balance between grand/white fir and “anchor” ponderosa pine. Understory trees, which are mostly shade tolerant species, are multi-aged, and well distributed. Trees (either ponderosa pine or grand/white fir) may occur as dense thickets when pioneering an opening created by insects/disease, fire or wind throw. Due to surrounding area influences, grand/ white fir does not comprise more than 30% of the area over 30 years. Snags and large down logs provide a significant amount of structural complexity.

Lodgepole pine

These areas are influenced by cold air drainages and in general have a longer disturbance interval, but can be influenced by the surrounding landscape and changes in insect/disease abundance (Simpson 2007, Stine 2014). Moderate to high intensity fire is the primary disturbance agent with return intervals of around 35 to 100+ years. Generally these areas are a mosaic of varying textures and seral stages and patch sizes and contain stands of generally similar aged/sized trees with few large ponderosa pine grand/white fir remnants.

The desired future condition includes safety along a travel corridor would include reduced fuel loading from recent fires and beetle epidemic thereby lowering risk to public/fire fighter safety near a visual and escapement corridor (16rd). Tree species diversity among the different stand conditions would be favored where such exists.

Forest Plan Direction

Management direction for the Melvin Butte project area is found in the Deschutes Land and Resource Management Plan (LRMP) as amended by the Northwest Forest Plan (1990). The entire project is within the range of the Northern Spotted Owl and therefore falls within the direction of the Northwest Forest Plan.

Deschutes National Forest Land and Resource Management Plan (LRMP)

Under the Deschutes National Forest LRMP, National forest lands are stratified into management areas (MA) which provide standards and guidelines for all natural resource management activities. LRMP management areas within the Melvin Butte project include General Forest (MA 8), Scenic Views (MA 9), Old Growth (MA 15), and Front Country Seen/Unseen (MA 18). A brief summary of the goals for these management areas are as follows:

General Forest (LRMP pages 4 - 117-120): The goal is to emphasize timber production while providing forage production, visual quality, wildlife habitat and recreational opportunities for public use and enjoyment. A small portion of the Melvin Butte project area, 1 acre (<1%) falls within this MA.

Scenic Views (LRMP pages 4 – 121-131): The goal is to provide Forest visitors with high quality scenery that represents the natural character of Central Oregon. A portion of the Melvin Butte project area, 1,265 (24%) falls within this MA and is mostly associated with the Metolius-Windigo Trail and the 16 rd.

Old Growth (LRMP pages 4 – 149-151): The goal is to provide old growth forest ecosystems for (1) habitat for plants and animal species associated with old growth forest ecosystems, (2) representations of landscape ecology, (3) public enjoyment of large, old-tree environments, and (4) the needs of the public from an aesthetic spiritual sense. Old growth areas will also contribute to the biodiversity of the forest. A small portion of the Melvin Butte project area, 167 acres (3%) falls within this MA and is entirely associated with Melvin Butte.

Front Country (LRMP pages 4 – 159-163): The goal is to provide and maintain a natural appearing forested landscape on the slopes northeast of the Three Sisters and Tam MacArthur Rim while providing high and sustainable levels of timber production. The majority of the Melvin Butte project area 3,943 acres (74%) falls within this MA.

Northwest Forest Plan

In addition to management direction found in the LRMP, the project area is managed under the Northwest Forest Plan (NWFP). The NWFP amended the LRMP in 1994. The project area contains two NWFP land allocations.

Matrix: The matrix consists of areas where most timber harvest and other silvicultural activities would be conducted, according to standards and guidelines. Most scheduled timber harvest takes place in the matrix.

Administratively Withdrawn: These areas are identified in current Forest Plans and include recreation and visual areas, back country, and other areas where management emphasis precludes scheduled timber harvest. In the project area this includes the butte in which the project is named “Melvin Butte”.

Table 12. NWFP allocations in the Melvin Butte Project

NWFP Management Allocations	Acres
Matrix	5,209
Administratively Withdrawn	167

Northwest Forest Plan Standard and Guideline C-44

This standard and guideline would apply to projects where little old growth remains at the corresponding 1/10th field (also known as 1/5th field) watershed. In this case the project area is within the Deep Canyon watershed and contains less than 15% old-growth fragments.

Under this project this standard and guideline is being met similarly among both action alternatives (Appendix D). This is accomplished by the pertinent treatment types (or lack thereof) to where these areas are located or by silvicultural prescription elements that describe the retention of old growth trees under differing treatment types (See Appendices D,E,F).

Environmental Consequences

Goals, Objectives, and Issues Addressed and Indicators for Assessing Effects

Goals, objectives, and issues are discussed above under Overview of Issues Addressed and Desired Condition.

Issues Addressed and Indicators for Assessing Effects

This analysis discloses the predicted effects of tree thinning and fuels reduction on forest health and sustainability. The direct factors analyzed herein, and those which influence meeting the purpose and need of the project are; forest/stand structure, stand densities, species composition and insects and disease risk. Actions that affect these factors are the type and amount of vegetation management (e.g. tree thinning, prescribed burning, and mowing), and extensive disturbances.

The primary biotic risk agents identified in the project area were tree densities, bark beetles and western dwarf mistletoe. Key measures of the effects of the alternatives on these agents are the following:

- Bark beetle risk reduction is measured in terms of the acres above the upper management zone treated with density-reducing treatments.
- Western dwarf mistletoe reduction is measured in terms of the acres of stands infected with western dwarf mistletoe treated to remove/reduce infection, and the number of acres above the upper management zone treated with density-reducing treatments.

The below key and analysis issues are discussed among the no action and two action alternatives below.

Table 13. Key Issues

Key Issue		Key Issue Indicator (s)
1	Temporary roads	1) Acres made assessable (by temporary road construction) 2) SDI
2	Group Opening in Mixed Conifer PAGs	1) Acres of openings 2) Past logging and fire suppression
3	Removal of large diameter dwarf mistletoe pine	1) Acres with potential large diameter heavily infested dwarf mistletoe pine tree removal.

Rationale within proposed action that resulted in Key Issue Development

Key Issue #1: No temporary roads

The proposed action of building 0.8miles of temporary road action was developed to allow access to about 70-90 acres in the project acre. About 71 of these acres allow access to land directly interfacing with private land (Skyline Forest). This temporary road construction consists of reutilizing old road beds and/or skid trails from previous harvest activities.

Key Issue #2: Do Not Include Group Openings in the Mixed Conifer Plant Association

This portion of the proposed action was developed to address the interacting effects of past logging and fire suppression/exclusion within the mixed conifer type on grand/white fir site dominance. The proposed action describes the implementation location of these openings in terms of high relative grand/white fir/ ponderosa pine proportions and retains ponderosa pine from any size class if they are healthy or have low mistletoe infection[12]. It is estimated that a maximum of 30% (range 10-30%) of a given unit would have these openings and would range in size from 1-3 acres. These areas will also have reintroduced prescribed fire to improve natural regeneration of ponderosa pine and may be planted if ponderosa pine regeneration is delayed.

Key Issue #3: Do not remove large diameter dwarf mistletoe pine

This portion of the proposed action was developed to assign specific locations where Deschutes National Forest Collaborative (DNFC) ponderosa pine dwarf mistletoe recommendations would be specifically applied. These areas represent 160 acres and would remove select large trees in strategic locations as outlined in recommendations. These recommendations would be interpreted and communicated (feed-back) before these trees are removed. Old growth ponderosa pine outside of these areas would be maintained however pruning or girdling may occur.

Table 14. Analysis Issues

Analysis Issue	Analysis Issue Indicator (s)	Measures
Forest Ecosystem Restoration	Stand density	SDI
	Old growth development	SDI
	Stand structures /species composition	Acres treated
	Insects and disease	SDI, DMR
	Fuels restoration	CBH, CBD, CI, fire type

Spatial and Temporal Context for Effects Analysis

Spatial and Temporal Bounds

The proposed action would occur within the project boundary and within the ponderosa pine, dry/wet mixed conifer and lodgepole types. Additional treatments are proposed within lodgepole stands, but are planned more as visual enhancement, fuels reduction or to open stands up for other in situ species (ponderosa pine).

Past, Present, and Foreseeable Activities Relevant to Cumulative Effects Analysis

The cumulative effects boundary includes a 1000ft buffer around the project area to account for adjacent vegetation changes/ effects. This includes eastern edge of the Pole Creek Fire and southern boundary of the SAFR project area.

[12] Relative proportion: These areas indicate current grand/white fir which was not previously the case prior to past overstory logging and fire suppression/exclusion policy. Determination of this condition was done by historic ponderosa pine stumps both through direct quantitative and qualitative assessments and through the review of literature. Mixed conifer in Melvin Butte indicates greater historic ponderosa pine proportion than current levels.

Direct and Indirect Effects

There are no treatments under the no action alternative, and therefore no direct effects.

Alternative 1 (No Action) – Ecological Trends

Forest Ecosystem Restoration Trends

No thinning, harvest, prescribed burning or mowing would occur within the project area under the no-action alternative. Stand structure and density under the no action alternative would continue to deviate from historical conditions in the following ways:

- Stands would continue to be dominated by small trees (<21 in. DBH).
- Stand structure of stands would consist of dense, multi-storied canopies, resulting in large areas of contiguous ladder fuels or plantations with uniform canopies under high density shrub layer.
- Dead fuel on the surface would continue to accumulate in the form of decadent brush, dead material from insect and disease mortality, limbs, and needles, adding to the fuels that have accumulated since the last burn cycle.
- There would be an increase in western dwarf mistletoe in ponderosa pine.

The shift in species composition towards fire intolerant species (lodgepole pine and grand/white fir) would continue with the following effects:

- There would be more fire-intolerant species (primarily grand/white fir) on the landscape, and there would be more ladder fuels from the fire-intolerant species in the understory.
- There would be more shorter-lived trees (i.e., lodgepole pine and grand/white fir).
- There would be more stress on overstory ponderosa pine.
- There would be an increased risk of future bark beetle outbreaks, which increases the fire hazard over the landscape.

Thinning towards historic forest conditions in order to promote sustainability and resiliency would be avoided. Stand structures, species composition, and hazardous fuels would continue to move further away from HRV proportions. Approximately 88% of the acres in the project area are above the upper management zone. These acres are considered at a higher risk for bark beetles (mountain and western pine beetle) mortality, stand replacement fire and dwarf mistletoe infection (Powell 1999). These high density areas will remain susceptible to dwarf mistletoe and bark beetle activity and the susceptibility will increase over time. High stand densities will result in the overall reduction in tree vigor among all size classes. A reduction in tree vigor will predispose those trees to the various insects and diseases that take advantage of low vigor/weakened trees (e.g. bark beetles and root diseases). The most significant effect of high stand densities will be the gradual loss of the existing historic large-tree component at a rate that is likely to be much faster than if stand densities had been reduced to lower density levels. Ponderosa pine dwarf mistletoe from all size classes would continue to spread down, out and within furthering spread within and adjacent plantations. Fuel buildup would continue contributing reductions in ponderosa pine natural regeneration. Lodgepole stands would continue to fall apart with areas within the Pole Creek fire and along the 16rd creating high down wood levels and impacting this escapement and visual corridor.

Stand Structures/Species Composition

Stand structures currently do not reflect the desired condition based on historical references, and are not likely to achieve this under no action (Youngblood 2006). Resistance and resilience to disturbance would remain low, since almost the large majority of stands are at or above the UMZ for stand density. Current fire suppression/exclusion policy and past logging has increased small trees that act to increase inter-tree competition (densities), fuel ladders and abundance and spread of dwarf mistletoe. Under the no action the interaction of these elements will continue and contribute to delays in old growth development and attenuation of current old growth trees overtime. Since small shade-tolerant trees would continue to persist and grow under the overstory, and new regeneration of shade-tolerant species would be recruited, the stand structures would continue to be multi-layered and to succeed to grand/white fir. There would be continued loss of the larger ponderosa pine, which are the most fire-resistant trees, and which "anchor" late-successional habitat from disturbance to disturbance by providing a long-lived component with the ability to survive wildfire. At the high stand densities found in this area, the larger, older trees are often the first to die, because under stress they are unable to maintain their higher respiratory requirements compared to smaller trees, and are susceptible to bark beetles (Fettig et al. 2007).

Dense younger stands in the project area also would not benefit from thinning treatments designed to create heterogeneity and increase growth. These stands are currently very dense (some areas exceed 1000 trees per acre), and thinning would move them towards reference conditions for density and species composition. Many plantations established after clearcutting since the 1960s are dense and even-aged. Pole size lodgepole and mixed conifer stands, some of which developed after partial-cutting, would continue to be dense and relatively even-aged/sized. Given the high levels of insects and disease within the project area, not thinning these younger stands to increase growth and moving them towards desired conditions would be a lost opportunity. Thinning would provide potential replacement habitat for mortality-prone mature stands sooner than no treatment.

In the event of a wildfire it is expected that fire behavior and stand replacement conditions would occur and be similar to that of the Pole Creek Fire 2012. As such a large proportion of the area would be set back to an earlier seral and structural state therefore resulting greater and longer delays in old growth development.

The growth and crown development of the smaller trees would also be affected by No Action. Trees in the smaller size classes (<21" dbh) would remain in high density conditions that are not conducive to good growth or crown development. The types of crowns developed by historic old-growth ponderosa pine did not occur under the high densities that the majority of the small trees in the Melvin Butte project are growing under now.

Stand Density

Stand densities would remain at high levels and generally increase over the next 30 years under No Action. Whether density increases in a given stand or stand-type or not will depend on the amount of density-dependent mortality and density-independent (insect/disease related) mortality that occurs. Both types of mortality are difficult to predict, and are often triggered by drought which intensifies the competition process among trees and weakens trees so that they are less able to resist insects and pathogens. However, given that existing densities exceed thresholds based on MaxSDI (50 percent of

MaxSDI) on over 4730 acres (see Tables 5,6), and given that mortality is already occurring, it is highly likely that mortality would continue and increase in the future. Stand densities will remain high and continue to increase in areas where they are already high. In areas where they may not already be high they will continue to increase, eventually reaching undesirable levels. Under the No Action alternative, the large tree component, as well as smaller trees, which represent future large trees, would exhibit low resistance to bark beetle attack, and higher risk of mortality from dwarf mistletoe. With continued competition from understory trees, mortality within the large tree component would be expected to increase. Losses would be especially pronounced under drought conditions.

No action alternative would result in the slowdown of the recruitment of large trees due to the continued density-related decline in tree growth and vigor. Stands would continue to decline in growth and vigor due to increasing competition and reduced crown development. Risk to insects and disease would continue to intensify. Increased bark-beetle activity would be anticipated with the next drought cycle.

Table 15. Existing and 2045 stand metrics for mixed conifer dry PAG.

Stand Metric	Existing Condition	Year 2045
Trees/acre	1425	965
Basal Area/acre (ft.^{2})	207	221
Canopy Cover (%)	64	63
SDI	467	472
% MaxSDI	69	67

Table 16. Existing and 2045 stand metrics for mixed conifer wet PAG

Stand Metric	Existing Condition	Year 2045
Trees/acre	1939	1464
Basal Area/acre (ft.^{2})	228	262
Canopy Cover (%)	65	66
SDI	551	586
% MaxSDI	84	89

Table 17. Existing and 2045 stand metrics for ponderosa pine PAG

Stand Metric	Existing Condition	Year 2045
Trees/acre	1575	522
Basal Area/acre	149	167

(ft.^{2})		
Canopy Cover (%)	55	54
SDI	335	333
% MaxSDI	87	88

Insects and Disease

Dwarf Mistletoe

Table 18. Western Dwarf Mistletoe Ratings by PAG

PAG	Existing Mean DMR (Avg. across all stands)	2045 Mean DMR (Avg. across all stands)
Ponderosa pine	2.02	4.08
Mixed Conifer	1.05	2.20
Lodgepole	0.80	1.35

Due to current levels of dwarf mistletoe, stand structures and densities the trends of dwarf mistletoe will increase substantially (Table 18). This can likely be explained by the numerous plantation and second growth blocks surrounded by medium to large heavily infested ponderosa pine (Figure 8). These trees would continue to spread mistletoe seeds down, within and outward filling in areas with low to medium infections. With a rate of 2-3 ft. /year in evenaged stands, currently infected plantations will be completely or nearly so enveloped with dwarf mistletoe in 2045. High stand densities are expected to increase large tree mortality and dwarf mistletoe infection and bark beetles interactions are expected to reduce large tree recruitment. Since dwarf mistletoe is specific to ponderosa pine, increases of grand/white fir is expected creating conditions that are further outside of reference conditions.

Re-Introduction of Fire

Re-introduction of fire for beneficial uses would be extremely difficult under the no action alternative due to the current propensity towards crown fire, mortality and adjacent private lands. Holding and suppression activities would place firefighters at risk due to dense understories which could lead to dangerous flaming fronts along potential hold lines. Anchor points would need to be established, which during suppression activities are usually done in haste as opposed to planned treatments executed by contracts.

Uncharacteristic Wildfire

Fire regimes in the ponderosa and mixed conifer PAG were historically primarily frequent/low to mixed severity regimes that consumed mostly understory fuels, vegetation with small pockets of torching. Predicted fire types now have substantial amounts of stand-replacing severity, which is considered uncharacteristic of these plant associations (Table 20, Agee 1994).

Table 19. Predicted fire type under No action (2019).

Fire type under severe conditions	Acres	% of project boundary
Active	2441	45
Cond. Crown	217	4

Passive Crown	1009	19
Surface	1705	32

Alternative 2 (Proposed Action) – Direct and Indirect Effects

Effects on Forest Ecosystem Restoration

Table 20. Alt 2 treatments and acres

Alt. 2 Treatment Type	Acres
Prescribed fire	809
Thinning	998
Mixed conifer group openings	835
Dwarf mistletoe areas	160
Lodgepole pine improvement	249
Plantations	1174
Scenic Views Enhancement	240
Retention Strategy Areas	775
No treatment	159

A total of 4,435 acres would be treated using a variety of treatment types to reduce tree and shrub density, increase average tree size, reduce fire-intolerant late-seral species, reduce abundance of mistletoe laden trees, enhance visuals and provide fuel breaks to protect people and property from wildfire from the project area (Table 20). Two hundred and forty of these acres will be a visual and WUI escapement corridor "clean up" of heavy fuel loading adjacent to the 16rd (Three Creeks Lake road). The no treatment areas correspond to Three Creek while the retention strategy areas correspond to different areas within the project boundary (see Wildlife report).

Stand Structures/Species Composition

Alternative 2 thinning and underburning treatments would move stands towards reference conditions. All treatments would lead to a greater patchwork distribution of size/age classes rather than the current continuous vertical and horizontal distribution of trees. Early seral, fire climax ponderosa pine species composition is improved by the number of acres treated which includes areas where this is the focus strategy (i.e. mixed conifer group openings).

Management practices aimed at maintaining vigorously growing stands can considerable reduce the potential impacts of insects and disease agents and enhance forest health (Hessburg, et.al. 1994). Under Alternative 2, thinning and harvest treatments would reduce competition stress on larger, older ponderosa pine by thinning from below. High densities and competing species (e.g. juniper and grand/white fir) can represent a considerable component of competition with older overstory pines. Reducing the small tree component and other competing species around older pines would provide needed growing space to keep overstory trees growing at rates that would allow them to be resistant to bark beetles and resilient to dwarf mistletoe.

Stand structure and species composition under Alternative 2 would be moved towards historical conditions in the following ways:

- On at least 4,201 treated acres, average diameter would be increased by cutting/removing smaller trees, increasing the resistance of those acres to fire.
- A larger increase of early seral (ponderosa pine) species proportion within the mixed conifer types by heavy thinning of fire intolerant species. This would include up to a maximum of 250 acres broken into 1-3 acre areas.
- Stand structure of most stands would still consist of multi-layered canopies, but the density and number of layers would be reduced and large areas of contiguous ladder fuels would be broken up and crown bulk densities would be reduced.
- Dead fuel on the surface in the form of decadent brush, dead material (from recent insects/disease/fire), limbs, and needles, would be treated along with activity created fuels.

The current trend, in some portions of the project area, in species composition towards fire intolerant species (juniper, lodgepole and grand/white fir) would be abated with the following effects:

- More fire- and disease-resistant species would occupy the landscape, and ladder fuels in the form of shade-tolerant trees in the understory would be reduced.
- Less fire intolerant species (juniper, lodgepole pine and grand/white fir) would occupy the landscape.
- There would be a reduction in competitive stress on overstory ponderosa pine.
- Species diversity would be maintained by retaining fire intolerant species in retention areas, no-treatment clumps/areas, riparian corridors as well as the higher productive plant associations.

Stand Density

On the project (Melvin Butte landscape) level, SDI moves from 88% max SDI (pre-treatment) to 44% max SDI (after thinning). This proportion change represents movement to between the lower and upper management zones for forest health. While specific areas within the project are still above the UMZ (60% Max SDI) (Table 21,22) and has sustained risk for insects/ disease and fire, other areas near or surrounding these are within the zone predicting these factors to be less likely. Plantation stands have received greatest release and are expected to develop into large trees more rapidly (assuming reduced mistletoe influences).

Table 21. Stand density metrics pre-and post-thinning (2016) for proposed action prescriptions

Rx	Acres	Pre-BA	Post-BA	Pre-SDI	Post-SDI	Post % MaxSDI	Pre-QMD	Post-QMD
Prescribed fire	779	200	153	470	307	53	5.6	8.8
Retention strategy areas	775	225	225	518	518	74	5.9	5.9
Lodgepole pine improvement	249	210	73	528	159	24	4.8	6.5
Plantations	1174	103	43	327	198	23	5.6	8.5

Dwarf Mistletoe	159	174	80	400	173	35	5.7	9.3
Thinning	998	174	119	448	208	43	5.9	11.4
Thinning w/group openings	835	237	102	559	219	33	5.5	8.0
No treatment	159	221	221	542	542	81	4.9	4.9
Note: Rx acres represent what was assigned in FSVeg SDA and are approximate due to GIS slivers and non-forest polygons (not assignable); all values are averages of all treated stands (retention strategy acres displayed for reference) Scenic views is omitted here since it was largely stand replacement and thus is in the grass/forb state with low live tree densities.								

Table 22. Stand density metrics pre- and post-thinning (2016) for predominate PAGs in project area.

PAG	Acres	Pre-BA	Post-BA	Pre-SDI	Post-SDI	Post % MaxSDI	Pre-QMD	Post-QMD
Lodgepole*	312	205	96	505	213	33	5.1	7.0
Ponderosa pine	1123	156	116	349	237	55	6.2	8.2
Mixed Conifer Dry	2123	212	129	489	276	40	5.7	7.7
Mixed conifer wet	1571	231	129	555	277	42	5.3	7.3
Note: These metrics represent stand metric averages across PAG treatment. * Lodgepole PAG metrics reported here include those areas outside the Pole Creek Fire 2012								

Insects and Disease

Variable thinning to lower SDI values and move stands towards reference conditions will have a positive effect on tree resilience against bark beetles and lightly (DMR1-3) infected dwarf mistletoe ponderosa pine. On the project level, dwarf mistletoe abundance is reduced by half and in 30 years levels are approaching the no action as mistletoe spread has impacted regeneration and other under/midstory trees. On the fine-scale (stand level), it is expected that strategic removal, pruning and girdling of point source locations including select large trees will aid in size development of ponderosa pine in fine-scale locations especially plantations and areas at least 100 ft. from mistletoe infected trees.

160 acre Dwarf Mistletoe Areas-

Variable thinning under and midstory trees and strategic removal of select overstory trees within 160 acre dwarf mistletoe emphasis areas will aid in reduced spread rates to coordinating and neighboring plantations promoting these areas to develop into the overstory. Follow up pruning of other trees and underburning in these areas will help reduce other point sources into and among stands. Outside of neighboring plantations, most of these areas will maintain a mistletoe component in the short and long-term.

Outside of 160 acre Dwarf Mistletoe Areas-

Variable thinning under and midstory trees will reduce mistletoe abundance within stands and create larger distances between crowns. Follow up underburning and pruning will aid in reduced infection levels when trees are killed by fire or point source locations are reduced from pruning. Natural regeneration or any overstory trees in these areas will continue to be infected and offer infections to neighboring understory trees. Isolating and confining groups of overstory trees with a thinning buffer will help reduce spread (outside the group) in the short term, but in the long-term rates are expected to return as regeneration occurs. Strategic thinning of moderately to heavily infected small to medium sized ponderosa, pruning or girdling will help promote resource reallocation to non- or lightly-infected ponderosa pine leave trees. These trees may become more resilient to dwarf mistletoe infection if their distances are at an adequate distance from mistletoe point sources. When this is the case they will be more likely to develop into larger size classes.

Table 23. Dwarf mistletoe rating after treatments in 2019 and 2045. Averaged across all stands in PAG.

PAG	2019 Mean DMR (Avg. across all stands)	2045 Mean DMR (Avg. across all stands)
Ponderosa pine	1.03	3.50
Mixed Conifer	0.85	1.95
Lodgepole	0.51	1.28

Large tree component

Thinning stands towards reference conditions to reduce density; adjust species proportions (favoring ponderosa pine over white fir); reduce dwarf mistletoe and reintroduce fire would have short-term albeit minor reduction in large trees (Table 24). In 30 years it is expected there will be an increase in the large ponderosa pine tree component across the project area as growing conditions are improved for large ponderosa pine tree recruitment/ development.

Table 24. Large tree per acre (TPA) change of across Melvin Butte project area under Alt. 2 old growth ponderosa and large and young white/grand fir among proposed action[13].

TPA (>21"dbh across Melvin Butte project area)	TPA >21"dbh after large and young white/ grand fir removal	TPA >21"dbh across all acres after implementation of Alt 2.	TPA >21"dbh across all acres in 2045
9.95	9.57	9.46	11.13

Potential for Crown Fire

Under the proposed action, the potential for crown fire is greatly reduced across the project as a whole (treated and untreated areas) as thinning, fuels work, underburning raises CBH and decreases CBD (table 25, 26). These changes increase the CI and reduces the potential for crown fire in all PAGs (table 27). Although, no treatment and retention areas maintain high CBH, CBH (table 26), acres treated show a marked decrease in the likelihood for stand replacement fire. Active crown fire is predicted to occur on

[13] This included simulation removal estimates of up to 1 strategic ponderosa pine per acre from 160 acres (in dwarf mistletoe units), 1 TPA white fir from 1000 acres of thinning units and 2 TPA from 835 acres of mixed conifer thinning units.

10% of the project area which is primarily allocated to retention strategy and no treatment areas (table 28).

Table 25. Potential fire metrics post-treatment under Proposed Action (2019)

PAG	Acres	Avg. CC	Avg. CBH	Avg. CBD	Avg. BA Mortality Severe Fire	Avg. CI
Lodgepole*	312	34	8	0.10	58	32
Ponderosa pine	1123	35	16	0.04	47	54
Mixed Conifer Dry	2123	36	17	0.06	58	46
Mixed Conifer Wet	1571	35	16	0.08	63	44
* Lodgepole PAG metrics reported here include those areas outside the Pole Creek Fire 2012						

Table 26. Potential fire metrics for treated areas under Proposed Action after treatments completed (2019).

PA Rx	Acres	Avg. CC	Avg. CBH	Avg. CBD	Avg. BA Mortality Severe Fire	Avg. CI
Prescribed fire	780	40	19	0.08	53	38
Retention strategy areas*	745	41	10	0.09	69	37
Lodgepole pine improvement	249	23	14	0.05	48	59
Plantations	1174	30	20	0.05	52	52
Dwarf Mistletoe	159	33	15	0.04	35	55
Thinning	998	38	15	0.05	53	44
Thinning w/group openings	835	30	17	0.06	55	53
No treatment areas	159	43	13	0.12	70	29
*These areas mimic no treatment areas, but were a deliberate strategy based on soils. Rx fire may occur with 30 acres of the 745 acres.						

Table 27. Predicted fire type post-treatment under Proposed Action, acres by PAG after treatments completed (2019).

PAG	Active Crown	Cond. Crown	Passive Crown	Surface	Totals
Lodgepole*	6	2	33	271	312
Ponderosa pine	0	0	399	725	1123
Mixed Conifer Dry	69	228	825	1000	2123
Mixed Conifer	311**	15	685	556	1567

Wet					
Note: totals may not exactly match proposed action figures due to GIS operations and rounding in SDA. * Lodgepole PAG metrics reported here include those areas outside the Pole Creek Fire 2012 **These acres are due to no treatment or retention strategy areas with the PAG					

Table 28. Predicted fire type post-treatment under Proposed Action, treated acres by Alt. 2 Rx (2019).

Rx	Active Crown	Cond. Crown	Passive Crown	Surface	Totals
Prescribed fire	7	79	36	657	779
Retention strategy areas*	431	0	84	260	775
Lodgepole pine improvement	0	0	86	163	249
Plantations	3	0	139	1032	1172
Dwarf Mistletoe	0	0	114	45	159
Thinning	0	7	190	800	997
Thinning w/group openings	0	40	131	664	835
No treatment areas**	61	0	24	74	159
Note: totals may not exactly match proposed action figures due to GIS operations and rounding in SDA *These areas mimic no treatment areas, but were a deliberate strategy based on soils. Rx fire may occur with 30 acres of the 745 acres. **No treatment areas are associated with Three Creek (riparian reserve)					

Uncharacteristic Wildfire

Alternative 2 greatly reduces the predicted mortality within treated areas, by changing the majority of the potential fire type acres to surface and passive crown (73% and 16% respectively, Table 28).

Alternative 2 – Cumulative Effects

All present and reasonably foreseeable future actions are designed to reverse the trends of past actions that have led the Whychus watershed away from HRV.

For cumulative effects to occur in terms of ecosystem restoration, fire behavior/severity and resilience/resistance to disturbance, those projects need to be within the project boundary or directly adjacent to this project.

The cumulative effects boundary includes a 1000ft buffer around the project area to account for adjacent effects due to fire spread and dwarf mistletoe from these areas. This area includes a portion of the Pole Creek Fire to the west and the SAFR project to the north. It is not known whether recent projects have or are going to occur east of the project on private lands. Boundary reconnaissance and aerial imagery review indicates low stocking and widely spaced trees in this area. The present vegetation management project and reasonably foreseeable future vegetation management projects in the Whychus watershed, under the current ecosystem principles, have or will be designed to minimize the loss of large trees and enhance the recruitment of trees into the medium/large tree category by favoring growth of dominant and co-dominant trees. The cumulative effects of the SAFR and Pole Creek Fire include higher fuels loads (hazard) to the west and untreated forest blocks (some with mistletoe) to the north. These combine to provide cumulative purpose/need for the proposed action for thinning within the project boundary for forest health and fuels reduction.

Besides that described above, there are no past, present or reasonably foreseeable projects that address the dense forest conditions, species proportions, fuels, provide for safety and visuals of evacuation routes, return fire as a natural disturbance process within or adjacent to the project area.

Alternative 3 – Direct and Indirect Effects

To address scoping key issues, the proposed action was modified into Alt. 3. These prescription modifications include: the removal of small group openings (1-3ac size areas up to 30%max of 835 acres) in the mixed conifer stands; retention of select large heavily infested ponderosa pine dwarf mistletoe trees in dwarf mistletoe units (160 acres) and avoidance of temporary road construction. As such, thinning modifications treatments become lumped under the “Thinning” analysis treatment type (Table 29, Chapter 2 EA). The avoidance of temp road construction automatically drops about 71 acres of “Thinning” with these acres located along private land in the southeast portion of the project. As such the direct and indirect effects in this section will be focused[14] on the “Thinning” and on the entire project as a whole.

Table 29. Alt 3 treatment type and acres.

Alt 3. Treatment Type	Acres
Prescribed fire	809
Thinning	1922
Thinning without group openings	
Lodgepole pine improvement	249
Plantations	1174
Scenic Views Enhancement	240
Retention Strategy Areas	775
No treatment	229

Effects on Forest Ecosystem Restoration

The major overarching difference between Alt 2 and Alt 3 has to do with changes in treatments acres, effects on species proportions and abundance and spread of dwarf mistletoe. Under Alt 3 total treatment acres are reduced by 71 acres and treatment type within 995 acres are altered.

[14] Analysis indicated similar results for Alt. 2 and Alt. 3 for plantations, lodgepole pine improvement, scenic views enhancement, underburning and retention strategy areas.

Stand Structures/Species Composition

There would be little difference in stand structures between Alt. 3 and Alt. 2 as stands are variably thinned from below lowering stand densities and reducing competition to larger trees. Treatment acres designed to address the effects of past selective logging and fire suppression (species composition implied) in the mixed conifer PAG by improving fire-tolerant localized ponderosa pine growing areas would be dropped. As a result, and in order to maintain stocking, fire intolerant species proportions would be retained. About 30% of the 835acres (250 acres maximum) would be maintained under a fire intolerant dominated trajectory.

Stand Density

On the project (Melvin Butte landscape) level density measures for Alt 3 are similar to Alt 2, SDI moves from 88% max SDI (pre-treatment) to 48% max SDI (after thinning). The 4% increase (from Alt. 2) is a result of treatment acres being dropped and altered. As a result, 321 acres are kept at higher densities with more of a fire intolerant tree composition with 71 acres directly next to private land.

Table 30. Alt 3 stand density metrics pre-and post-thinning (2016) for those treatment acres modified by Alternative 3 Rx proposed action prescriptions.

Rx	Acres	Pre-BA	Post-BA	Pre-SDI	Post-SDI	Post % MaxSDI	Pre-QMD	Post-QMD
Thinning	1922	214	124	498	273	46	5.7	13.2
No treatment	229	220	220	535	535	81	5.0	5.0
Note: Rx acres represent what was assigned in FSVeg SDA and are approximate due to GIS slivers and non-forest polygons (not assignable); all values are averages of all treated stands. Scenic views is omitted here since it was largely stand replacement and thus is in the grass/forb state with very little tree densities.								

Table 31. Alt 3 stand density metrics pre- and post-thinning (2016) for predominate PAGs in project area

PAG	Acres	Pre-BA	Post-BA	Pre-SDI	Post-SDI	Post % MaxSDI	Pre-QMD	Post-QMD
Ponderosa pine	1123	156	119	349	245	57	6.2	8.3
Mixed Conifer Dry	2123	212	139	489	301	44	5.7	7.1
Mixed conifer wet	1571	231	135	555	294	45	5.3	6.8
Note: These metrics represent stand metric averages across PAG treatment. * Lodgepole PAG was omitted since results are the same (see table 22).								

Insects and Disease

Thinning to lower SDI values and moving stands towards reference conditions will have a positive effect on tree resilience against bark beetles and lightly (DMR1-3) infected dwarf mistletoe ponderosa pine.

On the project level direct and indirect effects of dwarf mistletoe among Alt 3 and Alt 2 are similar (table 23, 32). At the project level dwarf mistletoe rating is reduced by about 1/3rd from existing levels and in 30 years those levels return to slightly below the no action for that year (table 23, 32). On the stand-scale, overstory influences into plantations and small medium small trees are maintained as large trees continue to provide mistletoe point source locations. Retaining any small trees underneath or adjacent to, highly infected ponderosa pine trees decreases the likelihood for large tree development (Eglitis et al. 2014). Overtime infestations will spread down, out and within infecting more and more of the plantations and adjacent area. Under this alternative managing for young ponderosa pine or replacement near highly infected trees, of any size, is challenged by reduced height/ diameter growth.

Table 32. Alt. 3 dwarf mistletoe rating in 2019 (post treatments) and 2045. Averaged across all stands within PAGs

PAG	2019 Mean DMR (Avg. across all stands)	2045 Mean DMR (Avg. across all stands)
Ponderosa pine	1.19	3.65
Mixed Conifer	0.88	2.02
Lodgepole	0.51	1.28

Potential for Crown Fire

On the landscape as a whole, crown fire potential reduced from no action though would be slightly higher than Alternative 2. This difference is due to the reduction in treatment acres and type within the ponderosa pine and mixed conifer types (Compare Table 24 and Table 31, 32).

Table 33. Potential fire metrics post-treatments under Alternative 3 (2019)

PAG	Acres	Avg. CC	Avg. CBH	Avg. CBD	Avg. BA Mortality Severe Fire	Avg. CI
Ponderosa pine	1123	37	16	0.04	49	49
Mixed Conifer Dry	2123	38	15	0.07	65	40
Mixed Conifer Wet	1571	40	14	0.09	69	37
Lodgepole PAG is omitted here due similar results as Alt 2 (see table 24)						

Table 34. Potential fire metrics for treated areas under Alternative 3 after treatments completed (2019).

PA Rx	Acres	Avg. CC	Avg. CBH	Avg. CBD	Avg. BA Mortality Severe Fire	Avg. CI
Thinning	1922	40	12	0.07	67	39
No treatment areas	229	44	12	0.13	75	27
Fire metrics for the remaining treatments are the same as those displayed in Table 25.						

Table 35. Predicted fire type post-treatment under Alternative 3, acres by PAG after treatments completed (2019).

PAG	Active Crown	Cond. Crown	Passive Crown	Surface	Totals
Ponderosa pine	0	0	398	725	1123
Mixed Conifer Dry	123	228	822	949	2122
Mixed Conifer Wet	311*	15	719	522	1567
Note: totals may not exactly match previous figures due to GIS operations and rounding in SDA. Lodgepole PAG is omitted here due similar results as Alt 2 * These acres are due to no treatment or retention strategy areas					

Table 36. Predicted fire type post-treatment under Alternative 3, those treatment acres modified by Alt 3. Rx (2019).

Rx	Active Crown	Cond. Crown	Passive Crown	Surface	Totals
Thinning	27	47	281	1566	1922
No treatment areas	61	27	68	74	229
Note: totals may not exactly match proposed action figures due to GIS operations and rounding in SDA. Fire metrics for the remaining treatments are the same as those displayed in Table 27.					

Uncharacteristic Wildfire

Access to about 70-90 acres of restoration units would be avoided with over ½ of this land directly interfacing with private land (2/3rd mile). As such, potential fire behavior and influences (egress) in these areas would be less predictable as current crowns have both horizontal and vertical fuel connectivity. Ongoing fire suppression/exclusion policy would continue and in the event of extreme wildfire fire behavior, related suppression tactics and existing conditions and trends; high severity sizes and proportions would range comparable to recent past fires (Eyery Fire 2002, Rooster Rock 2010, Pole Creek Fire 2012, Green Ridge Fire 2013, Bridge 99 Fire 2014, Whychus Watershed Analysis 2013).

Alternative 3- Cumulative Effects

Cumulative effects are the same as the proposed action.

All present and reasonably foreseeable future actions are designed to reverse the trends of past actions that have led the Whychus watershed away from HRV.

For cumulative effects to occur in terms of ecosystem restoration, fire behavior and severity and resilience/resistance to disturbance, those projects need to be within the project boundary or directly adjacent to this project.

The cumulative effects boundary includes a 1000ft buffer around the project area to account for adjacent effects due to fire spread and dwarf mistletoe. This area includes a portion of the Pole Creek Fire to the west and the SAFR project to the north. It is not known whether recent projects occurred to the east on private lands. Boundary reconnaissance and aerial imagery review indicates low stocking and widely spaced trees in this area. The present vegetation management project and reasonably foreseeable future vegetation management projects in the Whychus watershed, under the current management paradigm, have or will be designed to minimize the loss of large trees and enhance the recruitment of trees into the medium/large tree category by favoring growth of dominant and codominant trees.

The cumulative effects of the SAFR and Pole Creek Fire include higher fuels loads (hazard) to the west and north side of the project and untreated forest blocks (some with mistletoe) to the north. These combine to provide cumulative purpose/need for the proposed action for thinning for forest health and fuels reduction.

Besides that described above, there are no past, present or reasonably foreseeable projects that address the dense forest conditions, species proportions, fuels, provide for safety and visuals of evacuation routes, return fire as a natural disturbance process within or adjacent to the project area.

Other Effects- Action Alternatives

Contrasting Effects of Proposed Actions with Past Actions

The proposed action and other action alternative differ from previous actions in that tree removals would not be focused on the largest and most fire-resistant trees. All treatments are designed to leave the largest trees, improve heterogeneity and improve the composition of fire- and disease-resistant species. Rather than eliminating fire, prescribed fire is an integral part of these proposals.

Effects of Ongoing and Reasonably Foreseeable Actions

Similar restoration projects are being carried out within the Deschutes NF. In conjunction with these projects, it is likely that the potential for large uncharacteristic wildfires and bark beetle outbreaks in the project area would be reduced. Management options for the future would be increased. Wildland fire use may become more of an option, and the ability to implement long-term uneven-aged silviculture would be improved.

Combined Effects from Past, Proposed, Ongoing and Foreseeable Actions

Proposed, ongoing, and foreseeable actions are all geared towards restoring ecosystem structure and processes, and undoing the effects of most of the previous management consequences, whether they were intentional or not. It is expected that the combined effects would be positive in terms of maintaining healthy forests and the natural and human communities that depend on them.

NFMA Consistency

Suitability for Timber Production

Harvest units proposed on suitable lands have been reviewed by a certified silviculturist and determined that they are located on suitable lands and are capable of being regenerated within 5 years of timber harvest, although regeneration harvest is not being proposed in this project.

Regeneration Harvest and Even-aged Management

Treatments in this entry would provide future management options, including possibly the implementation of uneven aged systems on suitable sites. Regeneration harvest is not being proposed in this project, but rather planting of ponderosa pine and Douglas-fir would be done in alternative 2 to help shift the composition towards these more disease-resistant and historically dominant species in the long term.

Vegetative Manipulation

NFMA provides that timber harvest and other silvicultural practices shall be used to prevent damaging population increases of forest pest organisms, and treatments shall not make stands susceptible to pest-caused damage levels inconsistent with management objectives. Harvest of trees provides social and economic benefit, reduces potential losses attributed to insects and diseases, and manipulates forest vegetation to enhance wildlife habitat and/or meet associate objectives. The silvicultural prescription which directs the vegetative management process is designed to meet Forest Plan goals, objectives, and guidelines for forest productivity and wildlife habitat improvement while achieving ecosystem-based management.

Improvement harvest and commercial thinning are proposed for some stands in order to improve tree vigor of the desired leave trees and to maintain or enhance the plant diversity. NFMA provides for these treatments where they increase the growth rate of residual trees, favor commercially valuable species, favor species valuable to wildlife, or achieve some other multiple-use objective.

Regeneration Potential

NFMA specifies, "timber would be harvested from national forest system lands only where there is assurance that such lands can be adequately stocked within five years after final harvest" (16 USC 1604). Determination of adequate stocking is based on reforestation surveys conducted within a 5-year period following harvest or site preparation. Results of these stocking surveys are compared with the desired and minimum levels identified in a site-specific silvicultural prescription written for each treatment area. Restocking is considered satisfactory when the harvest area contains the minimum number, distribution, and species composition of vegetation specified in the prescription. There is no final harvest proposed in this project, and as discussed above, planting would be done with the objective of creating patches of younger, desired species.

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Appendix B- Glossary of Terms

Existing/Current Condition – Observed, qualitative and quantitative measures we used to describe density, Metrics are used to describe the existing condition. from planned AND unplanned actions taken over the last 150 years. in combination with the natural disturbance process on forested conditions. Some of the actions include (but aren't limited to) grazing, logging, fire suppression/exclusion, wildfires and insect and disease outbreaks.

Fire Severity- The effect a fire has on mortality specifically the amount of basal area loss due to fire effects.

Historic Range of Variation (HRV) – HRV of ecological conditions can be defined as the variation of historical ecosystem characteristics and processes over time and space scales that are relevant to land management decisions. This definition emphasizes that HRV describes a body of knowledge about historical ecological conditions without any explicit prescription for how that body of knowledge should be applied to land management decisions.

Seral stage (status): a stage of secondary successional development (secondary succession refers to an ecological process of progressive changes in a plant community after stand-initiating disturbance). Four seral stages are recognized: potential natural community, late seral, mid seral, and early seral (Hall et al. 1995).

- Early Seral: clear dominance of seral species (western larch, ponderosa pine, lodgepole pine, etc.); PNC species are absent or present in very low numbers.
- Mid Seral: PNC species are increasing in the forest composition as a result of their active colonization of the site; PNC species are approaching equal proportions with the seral species.
- Late Seral: PNC species are now dominant, although long-lived, early-seral tree species (ponderosa pine, western larch, etc.) may still persist in the plant community.
- Potential Natural Community (PNC): the biotic community that one presumes would be established and maintained over time under present environmental conditions; early- or mid-seral species are scarce or absent in the plant composition.

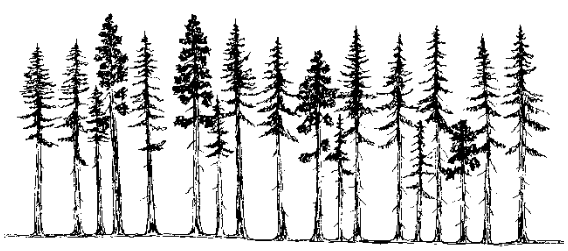
Structural stage (class): A stage or recognizable condition relating to the physical orientation and arrangement of vegetation; the size and arrangement (both vertical and horizontal) of trees and tree parts. The following structural stages have been described (O'Hara et al. 1996, Oliver and Larson 1996):

- Stand initiation: one canopy stratum of seedlings and saplings is present; grasses, forbs, and shrubs typically coexist with the trees.
- Stem exclusion: one canopy stratum comprised mostly of pole-sized trees (5-8.9" DBH) is present. The canopy layer may be open (stem exclusion open canopy) on sites where moisture is limiting, or closed (stem exclusion closed canopy) on sites where light is a limiting resource.
- Young forest multi strata: three or more canopy layers are present; the size class of the uppermost stratum is typically small trees (9-20.9" DBH). Large trees may be absent or scarce.

- Understory reinitation: two canopy strata are present; a second tree layer is established under an older overstory. Overstory mortality created growing space for the establishment of understory trees.
- Old forest: a predominance of large trees (> 21" DBH) is present in a stand with one or more canopy strata. On warm dry sites with frequent, low-intensity fires, a single stratum may be present (old forest single stratum). On cool moist sites without recurring underburns, multi-layer stands with large trees in the uppermost stratum may be present (old forest multi strata).

Table 37. Description of Forest Structural Classes By Developmental Stage and Size.

Stand Initiation (SI). Following a stand-replacing disturbance such as wildfire or timber harvest, growing space is occupied rapidly by vegetation that either survives the disturbance or colonizes the area. Survivors literally survive the disturbance above ground, or initiate growth from their underground roots or from seeds stored on-site. Colonizers disperse seed into disturbed areas, the seed germinates, and then new seedlings establish and develop. A single canopy stratum of tree seedlings and saplings is present in this class.



Stem Exclusion (SECC or SEOC). In this stage of development, vigorous, fast-growing trees that compete strongly for available light and moisture occupy the growing space. Because trees are tall and reduce sunlight, understory plants (including smaller trees) are shaded and grow more slowly. Species that need sunlight usually die; shrubs and herbs may become dormant. In this class, establishment of new trees is precluded by a lack of sunlight (stem exclusion closed canopy) or of moisture (stem exclusion open canopy).

Understory Reinitation (UR). As a forest develops, new age classes of trees (cohorts) establish as the overstory trees die or are thinned and no longer fully occupy growing space. Regrowth of understory vegetation then occurs, and trees begin to develop in vertical layers (canopy stratification). This class consists of a sparse to moderately dense overstory with small trees underneath.

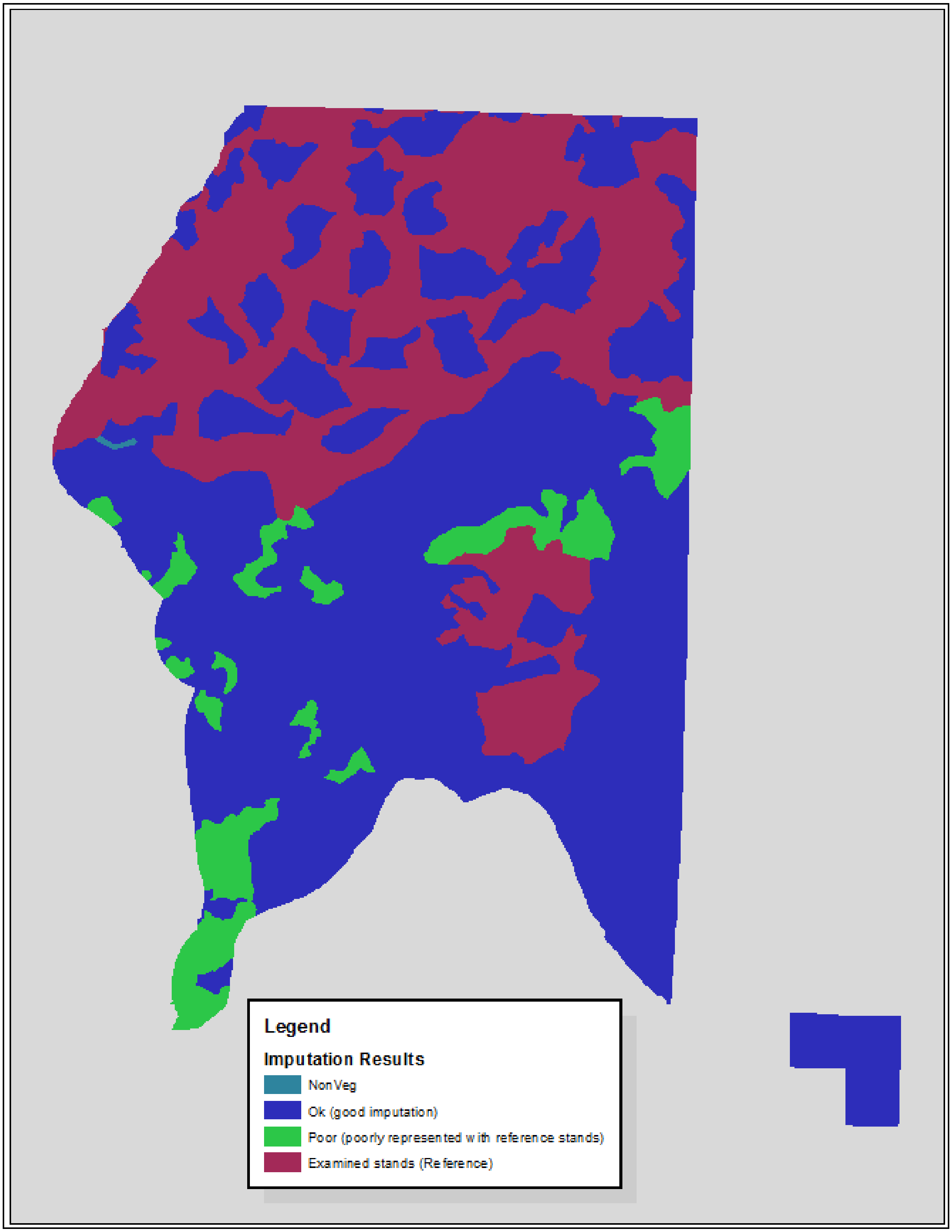
Young Forest Multi Strata (YFMS). In this stage of forest development, three or more tree layers are present as a result of canopy differentiation or because new cohorts of trees got established. This class consists of a broken or discontinuous overstory layer with a mix of tree sizes present (large trees are absent or scarce); it provides high vertical and horizontal diversity. Less than 10 trees per acre less than 21” in diameter. This class is also referred to as “multi-stratum, without large trees” (USDA Forest Service 1995).

Old Forest Multi-Stratum (OFMS). Many age classes and vegetation layers mark this structural class and it usually contains large, old trees. Decaying fallen trees may also be present that leave a discontinuous overstory canopy. On Cool Moist sites without recurring underburns, multi-layer stands with large trees in the uppermost stratum may be present. 10 or more trees per acre that are 21” in diameter

Old Forest Single Stratum (OFSS). Much age classes but only a single fairly distinct overstory layer marks this structural class and it usually contains large, old trees. Decaying fallen trees may also be present that leave a discontinuous overstory canopy. The diagram shows a single-layer stand of ponderosa pine that evolved with high frequency, low-intensity fire 10 or more trees per acre that are 21” in diameter

Sources/Notes: Based on Oliver and Larson (1996) and O’Hara and others (1996). Modified, Tatum 2006

Appendix C- Nearest Neighbor Run- Metadata



```
                                 NnReport.txt
Nearest Neighbor Run Database:
E:\AnalyzerTest1\ArcGIS10.1\Region_6\Deschutes\des_nn2704_t2\NearestNeighbor\Runs\SO
_MSN_C1_C2\NnSettings.mdb
Nearest Neighbor Y (Intensive) Data Database:
E:\AnalyzerTest1\ArcGIS10.1\Region_6\Deschutes\des_nn2704_t2\BaseData\FVS_Summary.md
b
Nearest Neighbor X (Extensive) Data Database:
E:\AnalyzerTest1\ArcGIS10.1\Region_6\Deschutes\des_nn2704_t2\NearestNeighbor\Bin\NnE
xtData.mdb


FSVeg Spatial Data Analyzer Nearest Neighbor Report

2015-02-12 15:24:19
Dataset: des_nn2704_t2
Method: msn
Scenario: SO_MSN_C1_C2
Description: Most-Similar Neighbor(MSN)  imputation for the SO FVS Variant.  Uses
the MSN statistical process to impute the data.

Use the following information to evaluate the run.
As with any statistical package, care should be taken when using the results.

====================================================================================
---
                                MSN Evaluation Info
====================================================================================
===
For a statistically valid run, it is recommended that all of these
checks pass before using the output of this imputation run.

CHECK 1: Check for Statistical Validity

Number of variates used is: 9
                Variate check: Adequate number of variates

CHECK 2: Check for the Quality of the Run

Canonical R Squared of 1st variate is:  0.967274485104924
                Canonical R Squared of the 1st Variate Check:
                                Adequate canonical R squared of the 1st variate.

Canonical R Squared of the First Variate, evaluation information:
 Value    . Evaluation Information
 < .6     | Not suggested for use without further review.
 .6 - .7  | Generally for broad general use without further review.
 .7 - .8  | Generally considered adequate for project use.
 > .8     | Generally considered dependable for EA modeling.

====================================================================================
===
                                MSN Run Statistics
====================================================================================
===
Reference Stand Info:
Number of reference stands used is: 154
There were 10 notably large differences among reference observations.
This represents 6.49 percent of the 154 references.
Threshold value calculated: 1.71

Threshold value used: 1.59
Imputed Stand Info:
Number of target imputations is: 1466
                                    Page 1
```

NnReport.txt

There were 155 notably large differences between reference and target observations.
This represents 10.57 percent of the 1466 imputations.

Total number of forested (reference and imputed) stands: 1620

Percentage of stands:
Below threshold = 90.43%
Above threshold = 9.57%

90.43 of the stands were well represented by the imputation run.
The remaining percentage did not have similar reference stands, hence
all available reference options could be statistically poor. These
stands will be displayed as 'Poor' on the map.

Threshold values are used to help indicate which stands may not be well
represented by the imputed values. The analyst should carefully evaluate all
imputed stands based on local knowledge with particular care to stands
labeled 'Poor' on the map.

Applies to reference stands only:
Mean Y RMSDS - Evaluation Variables: 0.895193987701582
Generalized Y RMSD - Evaluation Variables: 1.17166909709659

===

MODEL RESULTS INFORMATION

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Use the Mean RMSDS values to compare the quality of this
imputation to that of other Scenarios.

Root Mean Squared Differences

RMSD = Root Mean Squared Difference
RMSDS = Root Mean Squared Difference Scaled

*** Evaluation Variables ***
These variables are reference stand based. They are important variables
chosen by the analyst for the project to be analyzed.
They are used by the imputation run as the goal for prediction. Smaller
RMSDS values indicate better predictability of the variable.
This set of variables remains static for ALL scenario (nearest neighbor)
runs in this imputation dataset project.

Y (Intensive)

	RMSD	RMSDS
ZVOL_MH	26.8288410	0.579062
ZVOL_WF	484.1177338	0.645819
Canopy_Density	0.0505825	0.671861
SDI	105.6059202	0.685573
TCuFt	1537.7434872	0.714201
ZVOL_DF	71.0956195	0.716619
BA	44.2393872	0.735385
ZVOL_ES	64.3705584	0.748101
MCuFt	1415.0299501	0.762804
BdFt	8937.1611537	0.784425
CCF	62.2800546	0.800648
Crown_Index	8.8107420	0.809126
Tpa	695.0173267	0.817242
TopHt	11.2131069	0.834196
Total_Cover	10.4097856	0.839059

Page 2

```
QMD                 2.0707926 0.850180
ZVOL_LP           169.9917177 0.889998
ZVOL_PP           477.2603290 0.933560
ZVOL_NF             4.5582755 1.000000
ZVOL_RA            10.2631826 1.000000
ZVOL_WB            17.2647966 1.009971
ZVOL_WJ             9.5045812 1.013665
Fuel_Mod1           1.0751019 1.058454
Surf_Flame_Sev      1.5092093 1.078248
Canopy_Ht           7.9253825 1.128400
Torch_Index        51.5402483 1.239491
ZVOL_AF           213.3914410 1.305129
ZVOL_AS            28.8117572 1.414214
ZVOL_OH             0.0000000       NA

Mean Y RMSDS: 0.895193987701582
Generalized Y RMSD:   1.17166909709659

X (Extensive)
                         RMSD    RMSDS
Elev_m            141.0441626 0.558434
utmy             5107.8015905 0.689398
LSat8_B2_m        262.6662698 0.854400
LSat8_B3_m        301.6872738 0.861847
LSat8_B5_m        872.6793099 0.868525
LSat8_B10_m      1578.4526371 0.870197
LSat8_B11_m      1124.0192546 0.883357
LSat8_B4_m        555.4578089 0.922843
LSat8_B6_m       1735.1807930 0.976940
LSat8_B7_m       1482.2697963 0.988203
Prendvi_m           0.0519329 1.028425
utmx             3369.3278675 1.032980
Tancrv_sd           0.0827361 1.067706
Dur_m             231.0058576 1.080755
LSat8_B5_sd       243.8194420 1.086062
Slope_m             5.7261671 1.097536
Tancrv_m            0.0918315 1.106247
LSat8_B2_sd        67.1958044 1.118680
Cti_m               1.1331337 1.125613
Slpcosasp_sd        0.0456555 1.146473
LSat8_B3_sd        85.4453451 1.155701
Inso_m         106649.7561073 1.161212
LSat8_B6_sd       411.9719065 1.172966
Slpcosasp_m         0.1379086 1.184032
LSat8_B10_sd      321.9966155 1.185881
LSat8_B11_sd      227.8303217 1.186483
Elev_sd            14.1957761 1.190967
Inso_sd         33215.1384404 1.196396
Plncrv_m            0.0672691 1.224921
Cti_sd              0.4185160 1.225564
LSat8_B7_sd       352.3761815 1.242397
Slope_sd            1.9848516 1.242641
Dur_sd             91.5074879 1.264714
Plncrv_sd           0.0676611 1.267342
LSat8_B4_sd       154.8363671 1.277034
Slpsinasp_sd        0.0557510 1.395736
Slpsinasp_m         0.1192304 1.472049
Prendvi_sd          0.0122432       NA

Mean X RMSDS: 1.09217987119384
Generalized X RMSD:   1.22301930462468

================================================================================
```

```
===

*** Fit Variables ***
These variables are the actual variables used in calculating this imputation.
These variables may change based on the imputation method used. They can also be
manipulated by the analyst to test different scenarios to improve overall
imputation results.


Y (Intensive):
                    RMSD     RMSDS
LogVOL_WF       1.529332 0.508272
LogVOL_DF       0.685524 0.527404
LogVOL_MH       0.618822 0.594365
LogVOL_PP       1.266396 0.606459
LogSDI          0.289656 0.639858
SDI           105.605920 0.685573
LogBA           0.277699 0.698138
LogCCF          0.317008 0.722510
BA             44.239387 0.735385
LogBdFt         0.507162 0.742729
LogVOL_AF       1.102121 0.750699
LogTpa          0.669464 0.755002
LogVOL_LP       1.718386 0.775067
LogVOL_ES       0.893721 0.780152
BdFt         8937.161154 0.784425
CCF            62.280055 0.800648
Tpa           695.017327 0.817242
TopHt          11.213107 0.834196
Total_Cover    10.409786 0.839059
LogTopHt        0.156861 0.841640
QMD             2.070793 0.850180
LogQMD          0.325625 0.926672
LogVOL_NF       0.325183 1.000000
LogVOL_RA       0.390586 1.000000
LogVOL_WJ       1.180232 1.054613
LogVOL_WB       0.576275 1.135831
LogVOL_AS       0.630508 1.414214


X (Extensive):
                        RMSD     RMSDS
Elev_m           141.0441626 0.558434
dd0               60.5005255 0.572399
mmin               0.1993198 0.575144
mtcm               0.3469443 0.581945
mtwm               0.5247398 0.594290
dd5               99.5165350 0.595096
d100               7.5903203 0.595111
mmax               1.0454841 0.604069
utmy            5107.8015905 0.689398
gsp               28.2329267 0.721324
gsdd5             48.6268736 0.763452
sday               2.3717733 0.811747
LSat8_B2_m       262.6662698 0.854400
LSat8_B3_m       301.6872738 0.861847
LSat8_B5_m       872.6793099 0.868525
LSat8_B10_m     1578.4526371 0.870197
LSat8_B11_m     1124.0192546 0.883357
LSat8_B4_m       555.4578089 0.922843
ffp                5.2262986 0.945783
LSat8_B6_m      1735.1807930 0.976940
LSat8_B7_m      1482.2697963 0.988203
```

```
pSite               6.2370011 1.022573
Prendvi_m           0.0519329 1.028425
utmx             3369.3278675 1.032980
Tancrv_sd           0.0827361 1.067706
Dur_m             231.0058576 1.080755
LSat8_B5_sd       243.8194420 1.086062
Slope_m             5.7261671 1.097536
Tancrv_m            0.0918315 1.106247
LSat8_B2_sd        67.1958044 1.118680
Cti_m               1.1331337 1.125613
Slpcosasp_sd        0.0456555 1.146473
LSat8_B3_sd        85.4453451 1.155701
Inso_m         106649.7561073 1.161212
LSat8_B6_sd       411.9719065 1.172966
Slpcosasp_m         0.1379086 1.184032
LSat8_B10_sd      321.9966155 1.185881
LSat8_B11_sd      227.8303217 1.186483
Elev_sd            14.1957761 1.190967
Inso_sd         33215.1384404 1.196396
Plncrv_m            0.0672691 1.224921
Cti_sd              0.4185160 1.225564
LSat8_B7_sd       352.3761815 1.242397
Slope_sd            1.9848516 1.242641
Dur_sd             91.5074879 1.264714
Plncrv_sd           0.0676611 1.267342
LSat8_B4_sd       154.8363671 1.277034
Slpsinasp_sd        0.0557510 1.395736
Slpsinasp_m         0.1192304 1.472049
Prendvi_sd          0.0122432       NA

=====================================================================================
===
                                    MODEL RUN INFORMATION
=====================================================================================
===
This section lists X (Extensive) and Y (Intensive) variable usage
in the model run including what was selected for use, what was
used, and what was dropped.

X (Extensive) = These variables represent data populated in
        all polygons (e.g. slope, aspect, etc.)
Y (Intensive) = These variables represent data populated in sampled
        polygons (e.g. tpa, ba, etc.)


Fit Variables Selected In Scenario
X (Extensive):
 [1] Cti_m        Cti_sd       d100         dd0          dd5
 [6] Dur_m        Dur_sd       Elev_m       Elev_sd      ffp
[11] gsdd5        gsp          Inso_m       Inso_sd      LSat8_B10_m
[16] LSat8_B10_sd LSat8_B11_m  LSat8_B11_sd LSat8_B2_m   LSat8_B2_sd
[21] LSat8_B3_m   LSat8_B3_sd  LSat8_B4_m   LSat8_B4_sd  LSat8_B5_m
[26] LSat8_B5_sd  LSat8_B6_m   LSat8_B6_sd  LSat8_B7_m   LSat8_B7_sd
[31] mmax         mmin         mtcm         mtwm         Plncrv_m
[36] Plncrv_sd    Prendvi_m    Prendvi_sd   pSite        sday
[41] Slope_m      Slope_sd     Slpcosasp_m  Slpcosasp_sd Slpsinasp_m
[46] Slpsinasp_sd Tancrv_m     Tancrv_sd    utmx         utmy

Y (Intensive):
 [1] BA         BdFt       CCF        LogBA      LogBdFt    LogCCF
 [7] LogQMD     LogSDI     LogTopHt   LogTpa     LogVOL_AF  LogVOL_AS
[13] LogVOL_DF  LogVOL_ES  LogVOL_LP  LogVOL_MH  LogVOL_NF  LogVOL_OH
[19] LogVOL_PP  LogVOL_RA  LogVOL_WB  LogVOL_WF  LogVOL_WJ  QMD
```

```
                                   NnReport.txt
[25] SDI          TopHt       Total_Cover Tpa

Fit Variables Dropped due to NULL Data:
Y (Intensive):
               None.
X (Extensive):
               None.

Fit Variables Dropped due to Lack of Variance:
Y (Intensive):
               None.
X (Extensive):
               None.

Fit Variables Dropped by Model
Y (Intensive):
[1] LogVOL_OH

X (Extensive):
               None.

Fit Variables Used by Model (Excludes Variables Dropped)
X (Extensive):
 [1] Cti_m        Cti_sd       d100         dd0          dd5
 [6] Dur_m        Dur_sd       Elev_m       Elev_sd      ffp
[11] gsdd5        gsp          Inso_m       Inso_sd      LSat8_B10_m
[16] LSat8_B10_sd LSat8_B11_m  LSat8_B11_sd LSat8_B2_m   LSat8_B2_sd
[21] LSat8_B3_m   LSat8_B3_sd  LSat8_B4_m   LSat8_B4_sd  LSat8_B5_m
[26] LSat8_B5_sd  LSat8_B6_m   LSat8_B6_sd  LSat8_B7_m   LSat8_B7_sd
[31] mmax         mmin         mtcm         mtwm         Plncrv_m
[36] Plncrv_sd    Prendvi_m    Prendvi_sd   pSite        sday
[41] Slope_m      Slope_sd     Slpcosasp_m  Slpcosasp_sd Slpsinasp_m
[46] Slpsinasp_sd Tancrv_m     Tancrv_sd    utmx         utmy

Y (Intensive):
 [1] BA          BdFt        CCF         LogBA       LogBdFt     LogCCF
 [7] LogQMD      LogSDI      LogTopHt    LogTpa      LogVOL_AF   LogVOL_AS
[13] LogVOL_DF   LogVOL_ES   LogVOL_LP   LogVOL_MH   LogVOL_NF   LogVOL_PP
[19] LogVOL_RA   LogVOL_WB   LogVOL_WF   LogVOL_WJ   QMD         SDI
[25] TopHt       Total_Cover Tpa



=======================================================================
Warning(s) and/or error(s) produced during this NN imputation (by yaImpute):
Warning message:
In yai(y = intFitTable, x = extFitTable, method = yaiMethod,  ... :
  y variables with zero variance: LogVOL_OH

=======================================================================

                                    Page 6
```

Appendix D- Northwest Forest Plan Standard and Guideline C-44 Analysis. Provide for retention of old-growth fragments in watersheds where little remains

The Deep Canyon (1/5th field) watershed consists of a wide range of biophysical environments that include inherent soil limitations to tree growth, from alpine meadows to xeric shrublands and as such only a portion of the watershed can support development of trees let alone large trees that develop into an assemblage that becomes old growth habitat for late successional species (Craigg et al. 2015).

The old growth fragments/ patches[15] in the Deep Canyon Watershed and Melvin Butte Project area are displayed in Appendix F and total 1,188 acres at the watershed scale. Six hundred and sixty-two of these acres are within the Melvin Butte project boundary (Table 38, 39). In addition, these old growth patches/fragments in the watershed are disproportionally located to public (primarily Forest Service lands) and/or to biophysical environments more productive in nature (Simpson 2007, Appendix F, Table 38).

Over ½ (about 56%) of the entire watershed's large tree patches/ fragments are contained within Melvin Butte project area (Appendix F). The large tree patches/ fragments were further analyzed among the differing Melvin Butte project treatment descriptions areas which are presented below (Table 39). This analysis was chosen in order to demonstrate meeting Standard and Guideline C-44 of the Northwest Forest Plan.

Retention of Melvin Butte old growth patched/ fragments are being met in several ways under either action alternatives. The below acre proportions come from the 662 acres found within Melvin Butte project area. These are broken out by Alternative 2 treatment type

1) Retention strategy and other areas (ex. Three Creek) that are absent of thinning treatment.
    a. 33% of the old growth fragments/ patches found within Melvin Butte project area are in these areas.
2) Restriction of treatments to prescribed fire and/or 8"dbh thinning limit in Prescribed Fire treatment units.
    a. 30% of the old growth fragments/patches found within Melvin Butte project area are in these treatment areas and would not be impacted due to nature of small understory tree thinning and use of low intensity prescribed fire.
3) Retention of all old growth ponderosa pine clumps/ areas within the 160 acre Dwarf Mistletoe Units when they meet clump designation quota (at least four 21" ponderosa pine within a connected 66ft distance between trees).
    a. Less than 1% of the old growth fragments/ patches within Melvin Butte area are contained in this treatment type and by Lidar determination process[15] (and above parameter) provides retention of old growth.

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[15] Old growth patch size/ fragment determination came from a Lidar process of using a 30meter raster in order to determine large tree assemblages (number of large (>21"dbh) trees per 30 meter grid) that meet (or exceed) the Interim Old Growth Guide1993. Areas determined by Lidar analysis and consist of a height derived diameter. See correlation variables including diameter in Appendix E.

4) Unit by unit silvicultural implementation prescriptions that describe retention of old growth structure, composition (and accentuation) where present. Retention to include old growth ponderosa pine and old growth white fir and other species (where present) to a frequency that maintains large tree structure/ frequency across stands and maintains the definition as described in the Interim Old Growth Definitions (USDA 1993).
    a. 30% of the old growth patches/ fragments acres are contained in the Thinning treatment description areas.
        i. All prescriptions call for the retention and/or accentuation of old growth trees to maintain or exceed definitions (VanPelt 2008, USDA 1993).
    b. Less than 4% of the old growth patches/ fragments acres are contained in the Mixed Conifer Group Opening treatment areas.
        i. All prescriptions call for retention of old growth ponderosa pine. Any and all openings would maintain ponderosa pine tree composition and structure.
    c. Less than 2% of the old growth patches/ fragments are contained in the Plantation treatment areas.
        i. No old growth will be cut in plantations; this number represents trees detected on the boundaries of these areas. Boundary trees may be pruned if infected with dwarf mistletoe.
    d. All other treatment areas do not contain these old growth patches/ fragments

Alternative 2 and Alternative 3 are nearly identical in retention proportions and needs met for Standard and Guideline C-44. Difference is “Thinning Treatment” (Item 4a above in this section) increases to 35% as those old growth patches/fragments acres from Dwarf Mistletoe and Mixed Conifer treatments are reclassified to “Thinning Treatment”. Under Alternative 3, Items 3 and 4b (above in this section) are not applicable. Thus unit by unit silvicultural prescriptions (Item 4ai above in this section) describes how old growth fragment/ patch retention would occur in these combined areas.

Table 38. Acres and proportions of the large tree patches/ fragments among different "subareas" within the Deep Canyon watershed.

	Acres	Old growth fragments/patches acres (Lidar determined based on large trees/acre)	Proportion of area with old growth patches/fragments (%)
Deep Canyon watershed	97,509	1,188	1.2%
Applicable assessment area due to pertinent biophysical environment	60,712	1,188	2.0%
FS land with pertinent biophysical environments	49,601	1105	2.2%
Private land with pertinent biophysical environments	47,908	83	0.2%

Table 39. Acres and proportions of the large tree patches/ fragments among the Melvin Butte treatment types.

	Total Acres	Old growth fragments/patches acres (Lidar determined based on large trees/acre)	Proportion of Melvin Butte old growth fragment/ patches acres by Alt 2. Treatment type[16] acres
Melvin Project	5,375	662	N/A
Retention strategy, no treatment and no thinning treatment areas	940	222	33%
Plantations	1174	13	2%
Prescribed fire (includes small tree thinning)	809	201	30%
Dwarf Mistletoe	160	2	0%
Mixed Conifer Group Openings	835	24	4%
Scenic Views Enhancement	240	0	0%
Lodgepole pine improvement	249	0	0%
Thinning	998	201	30%

[16] NOTE-this table is identical among Alternatives EXCEPT acre contribution from Mixed Conifer Group Openings AND Dwarf Mistletoe are added to the Thinning treatment type under Alternative 3.

Appendix E- Single Tree based Lidar vs. CVS plot Estimates by size class for TPA, TBA, QMD and AvgDBH

Trees per Acre Estimates by size class on 306 CVS Plots

Highlighted t Stats are different at the 95% Level

t-Test: Two-Sample Assuming Unequal Variances 1-5" dbh		
	CVS_TPA	*Lidar4_TPA*
Mean	370.6404255	136.4600828
Variance	131882.6949	16386.27071
Observations	282	305
Hypothesized Mean Difference	0	
df	345	
t Stat	10.25574613	
P(T<=t) one-tail	5.10527E-22	
t Critical one-tail	1.649282305	
P(T<=t) two-tail	1.02105E-21	
t Critical two-tail	1.966863909	

t-Test: Two-Sample Assuming Unequal Variances 5-10" dbh		
	CVS_TPA	*Lidar4_TPA*
Mean	100.4134228	96.85063333
Variance	7149.01854	4452.385431
Observations	298	300
Hypothesized Mean Difference	0	
df	564	
t Stat	0.571740964	
P(T<=t) one-tail	0.283862631	
t Critical one-tail	1.647559815	
P(T<=t) two-tail	0.567725262	
t Critical two-tail	1.964179027	

t-Test: Two-Sample Assuming Unequal Variances 10-15" dbh		
	CVS_TPA	*Lidar4_TPA*
Mean	34.67144128	35.18838488
Variance	838.7086225	727.5574274
Observations	281	291
Hypothesized Mean Difference	0	
df	564	
t Stat	-0.220728186	
P(T<=t) one-tail	0.412691982	
t Critical one-tail	1.647559815	
P(T<=t) two-tail	0.825383964	
t Critical two-tail	1.964179027	

t-Test: Two-Sample Assuming Unequal Variances 15-20"dbh		
	CVS_TPA	*Lidar4_TPA*
Mean	12.2565019	14.37524528
Variance	198.9590677	239.5564379
Observations	263	265
Hypothesized Mean Difference	0	
df	522	
t Stat	-1.644223654	
P(T<=t) one-tail	0.050366043	
t Critical one-tail	1.647777944	
P(T<=t) two-tail	0.100732085	
t Critical two-tail	1.964518942	

t-Test: Two-Sample Assuming Unequal Variances 20-25"dbh		
	CVS_TPA	*Lidar4_TPA*
Mean	6.864881517	8.060434783
Variance	172.8110525	107.3230013
Observations	211	207
Hypothesized Mean Difference	0	
df	398	
t Stat	-1.033773875	
P(T<=t) one-tail	0.150934811	
t Critical one-tail	1.648691174	
P(T<=t) two-tail	0.301869622	
t Critical two-tail	1.965942324	

t-Test: Two-Sample Assuming Unequal Variances 25-30" dbh		
	CVS_TPA	*Lidar4_TPA*
Mean	4.143203593	4.519210526
Variance	39.01663711	50.41719937
Observations	167	152
Hypothesized Mean Difference	0	
df	302	
t Stat	-0.500088524	
P(T<=t) one-tail	0.30868847	
t Critical one-tail	1.649914828	
P(T<=t) two-tail	0.617376939	
t Critical two-tail	1.967850227	

Total Basal Area per Acre Estimates for 1 hectare CVS Plots

Highlighted t Stats are different at the 95% Level

t-Test: Two-Sample Assuming Unequal Variances 1-5" dbh

	CVS_TBA	Lidar4_TBA
Mean	17.8556361	7.259096506
Variance	303.550322	48.44050589
Observations	282	305
Hypothesized Mean Difference	0	
df	363	
t Stat	9.534287233	
P(T<=t) one-tail	1.12084E-19	
t Critical one-tail	1.649062137	
P(T<=t) two-tail	2.24168E-19	
t Critical two-tail	1.966520641	

t-Test: Two-Sample Assuming Unequal Variances 5-10" dbh

	CVS_TBA	Lidar4_TBA
Mean	27.90859839	28.8628731
Variance	512.0043135	401.5890685
Observations	298	300
Hypothesized Mean Difference	0	
df	586	
t Stat	-0.545811087	
P(T<=t) one-tail	0.292701756	
t Critical one-tail	1.647458056	
P(T<=t) two-tail	0.585403512	
t Critical two-tail	1.964020461	

t-Test: Two-Sample Assuming Unequal Variances 10-15" dbh

	CVS_TBA	Lidar4_TBA
Mean	27.59199408	28.1768581
Variance	567.6735798	463.991389
Observations	281	291
Hypothesized Mean Difference	0	
df	560	
t Stat	-0.307624567	
P(T<=t) one-tail	0.379241199	
t Critical one-tail	1.647579178	
P(T<=t) two-tail	0.758482399	
t Critical two-tail	1.964209198	

t-Test: Two-Sample Assuming Unequal Variances 15-20" dbh

	CVS_TBA	Lidar4_TBA
Mean	19.56828208	23.1814323
Variance	513.5973882	646.4279888
Observations	263	265
Hypothesized Mean Difference	0	
df	520	
t Stat	-1.724032016	
P(T<=t) one-tail	0.042648198	
t Critical one-tail	1.647789211	
P(T<=t) two-tail	0.085296396	
t Critical two-tail	1.964536501	

t-Test: Two-Sample Assuming Unequal Variances 20-25" dbh

	CVS_TBA	Lidar4_TBA
Mean	18.42555065	21.60534771
Variance	1280.541067	788.7643468
Observations	211	207
Hypothesized Mean Difference	0	
df	397	
t Stat	-1.011660425	
P(T<=t) one-tail	0.156158308	
t Critical one-tail	1.648700863	
P(T<=t) two-tail	0.312316616	
t Critical two-tail	1.965957428	

t-Test: Two-Sample Assuming Unequal Variances 25-30" dbh

	CVS_TBA	Lidar4_TBA
Mean	16.71275404	18.36593919
Variance	644.7485986	845.705406
Observations	167	152
Hypothesized Mean Difference	0	
df	301	
t Stat	-0.538504749	
P(T<=t) one-tail	0.295313315	
t Critical one-tail	1.649931694	
P(T<=t) two-tail	0.590626631	
t Critical two-tail	1.967876531	

QMD Estimates by size class on 306 CVS plots

Highlighted t Stats are different at the 95% Level

t-Test: Two-Sample Assuming Unequal Variances 1-5" dbh

	CVS_QMD	Lidar4_QMD
Mean	3.124100322	3.176148974
Variance	0.400261379	0.161550857
Observations	282	305
Hypothesized Mean Difference	0	
df	469	
t Stat	-1.178960143	
P(T<=t) one-tail	0.119505901	
t Critical one-tail	1.648109068	
P(T<=t) two-tail	0.239011801	
t Critical two-tail	1.965034989	

t-Test: Two-Sample Assuming Unequal Variances 5-10"dbh

	CVS_QMD	Lidar4_QMD
Mean	7.19421051	7.368768361
Variance	0.515190781	0.291913138
Observations	298	300
Hypothesized Mean Difference	0	
df	552	
t Stat	-3.358203484	
P(T<=t) one-tail	0.000419302	
t Critical one-tail	1.647618745	
P(T<=t) two-tail	0.000838605	
t Critical two-tail	1.964270856	

t-Test: Two-Sample Assuming Unequal Variances 10-15"dbh

	CVS_QMD	Lidar4_QMD
Mean	12.03309547	12.08616591
Variance	0.579071282	0.303580875
Observations	281	291
Hypothesized Mean Difference	0	
df	509	
t Stat	-0.952561572	
P(T<=t) one-tail	0.170632186	
t Critical one-tail	1.647852769	
P(T<=t) two-tail	0.341264373	
t Critical two-tail	1.964635549	

t-Test: Two-Sample Assuming Unequal Variances 15-20" dbh

	CVS_QMD	Lidar4_QMD
Mean	17.00305224	17.03371057
Variance	0.479954934	0.405332618
Observations	263	265
Hypothesized Mean Difference	0	
df	522	
t Stat	-0.52934128	
P(T<=t) one-tail	0.298396879	
t Critical one-tail	1.647777944	
P(T<=t) two-tail	0.596793757	
t Critical two-tail	1.964518942	

t-Test: Two-Sample Assuming Unequal Variances 20-25" dbh

	CVS_QMD	Lidar4_QMD
Mean	22.14176069	22.00116601
Variance	0.950512772	0.648114646
Observations	211	207
Hypothesized Mean Difference	0	
df	404	
t Stat	1.60894777	
P(T<=t) one-tail	0.054204436	
t Critical one-tail	1.648634049	
P(T<=t) two-tail	0.108408872	
t Critical two-tail	1.965853275	

t-Test: Two-Sample Assuming Unequal Variances 25-30" dbh

	CVS_QMD	Lidar4_QMD
Mean	27.21090076	26.98034685
Variance	1.108094343	0.711710825
Observations	167	152
Hypothesized Mean Difference	0	
df	312	
t Stat	2.167181654	
P(T<=t) one-tail	0.015488641	
t Critical one-tail	1.649752124	
P(T<=t) two-tail	0.030977282	
t Critical two-tail	1.967596497	

Average DBH Estimates for 306 CVS Plots

Highlighted t Stats are different at the 95% Level

t-Test: Two-Sample Assuming Unequal Variances 1-5" dbh		
	CVS_AvgDBH	*Lidar4_AvgDBH*
Mean	2.958289881	3.021192084
Variance	0.469779373	0.162609905
Observations	282	305
Hypothesized Mean Difference	0	
df	447	
t Stat	-1.341374753	
P(T<=t) one-tail	0.090239956	
t Critical one-tail	1.648269625	
P(T<=t) two-tail	0.180479911	
t Critical two-tail	1.965285234	

t-Test: Two-Sample Assuming Unequal Variances 5-10"dbh		
	CVS_AvgDBH	*Lidar4_AvgDBH*
Mean	7.085147667	7.250806512
Variance	0.509009685	0.284763619
Observations	298	300
Hypothesized Mean Difference	0	
df	550	
t Stat	-3.213619665	
P(T<=t) one-tail	0.000693761	
t Critical one-tail	1.647628817	
P(T<=t) two-tail	0.001387522	
t Critical two-tail	1.964286551	

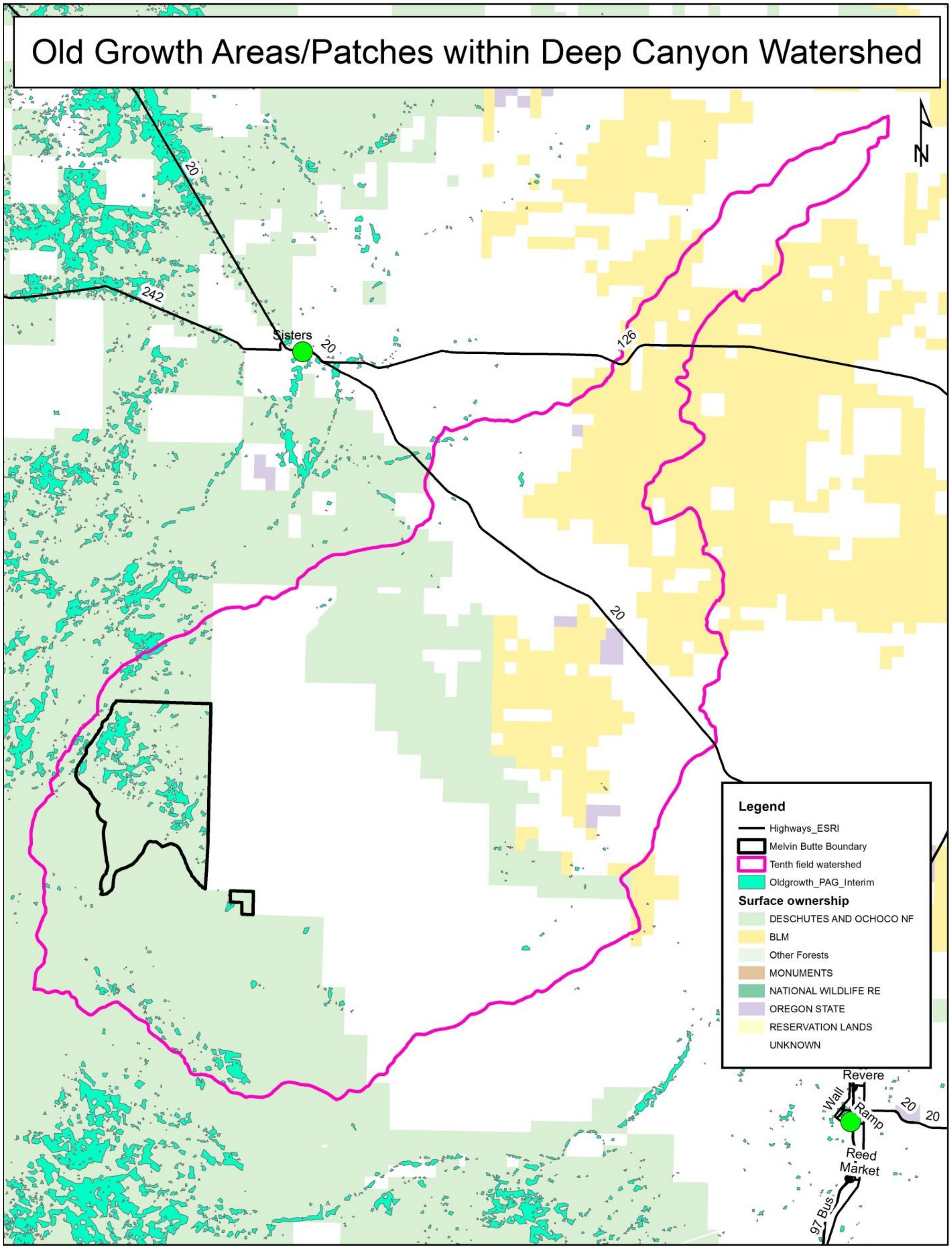
t-Test: Two-Sample Assuming Unequal Variances 10-15" dbh		
	CVS_AvgDBH	*Lidar4_AvgDBH*
Mean	11.97217533	12.01505557
Variance	0.577570809	0.29352981
Observations	281	291
Hypothesized Mean Difference	0	
df	505	
t Stat	-0.77464995	
P(T<=t) one-tail	0.219454536	
t Critical one-tail	1.647876568	
P(T<=t) two-tail	0.438909071	
t Critical two-tail	1.964672639	

t-Test: Two-Sample Assuming Unequal Variances 15-20" dbh		
	CVS_AvgDBH	*Lidar4_AvgDBH*
Mean	16.95929056	16.98699133
Variance	0.470612234	0.394643242
Observations	263	265
Hypothesized Mean Difference	0	
df	521	
t Stat	-0.483778309	
P(T<=t) one-tail	0.314373239	
t Critical one-tail	1.647783567	
P(T<=t) two-tail	0.628746479	
t Critical two-tail	1.964527705	

t-Test: Two-Sample Assuming Unequal Variances 20-25" dbh		
	CVS_AvgDBH	*Lidar4_AvgDBH*
Mean	22.11570776	21.9698589
Variance	0.946344498	0.637749985
Observations	211	207
Hypothesized Mean Difference	0	
df	404	
t Stat	1.676760114	
P(T<=t) one-tail	0.047181472	
t Critical one-tail	1.648634049	
P(T<=t) two-tail	0.094362944	
t Critical two-tail	1.965853275	

t-Test: Two-Sample Assuming Unequal Variances 25-30" dbh		
	CVS_AvgDBH	*Lidar4_AvgDBH*
Mean	27.19139361	26.95802043
Variance	1.105058684	0.697603855
Observations	167	152
Hypothesized Mean Difference	0	
df	311	
t Stat	2.204518185	
P(T<=t) one-tail	0.014109952	
t Critical one-tail	1.649767922	
P(T<=t) two-tail	0.028219904	
t Critical two-tail	1.967621133	

Appendix F- Locations of Lidar-derived old growth patches/ fragments within the Deep Canyon watershed and Melvin Butte Project area



Appendix G- Dwarf Mistletoe Background

Dwarf Mistletoe Spread Potential

Dwarf mistletoes possess one of the most effective, hydrostatically controlled, explosive mechanisms of seed dispersal known to flowering plants (Hawksworth 1977, USDA Agriculture Handbook 709, 1996). Maximum dispersal distance is about 48 feet, but dispersal distances of 30 feet or less are more typical. Studies of three species of dwarf mistletoe have indicated about 40 percent of dispersed seeds are intercepted by trees (Hawksworth 1965b). For example, an adjoining tree within 18 to 27 feet of an infected host would intercept 90 percent of the seeds dispersed in its direction. Germination is largely determined by environmental factors, but most mistletoe germinates in the spring following fall dispersal. Once infection is established, an incubation period of two to five years elapses before young shoots appear and the cycle of infection continues. In single-storied stands, spread is estimated to be two to three feet per year. Spread in multi-storied stands (which is largely the stand structure in the Melvin Butte area) is more rapid because the understory trees are exposed to infection from the overstory (Forest Insect and Disease Leaflet, USDA 2003).

Prior management practices beyond fire exclusion may have also played a role in increasing the rate of infection. Early harvest practices emphasized removal of mature, large diameter ponderosa pine which were at high risk of attack by western pine beetle. Smaller, understory trees were often retained. Where fire would have killed many of those that were infected with western dwarf mistletoe, they now would remain.

Severity of infection from dwarf mistletoe with a Dwarf Mistletoe Rating (DMR) scale from 1 (light) to 6 (severe). Individual trees with a DMR of 3 or less and stands with an average rating of less than or equal to 2 have a higher likelihood of being effectively managed through unevenaged thinning treatments and attaining old forest structure.

Roth and Barrett (1985) investigated the response after thinning ponderosa pine in central Oregon. Dependent upon the site potential of the stand, they found that if crowns enlarged at a faster rate than dwarf mistletoe propagates, thinned trees would grow quite productively. They found that while the population of dwarf mistletoe plants increases dramatically following thinning, it does so at about the same rate as the increase in the size of the tree crown. The ratio of number of plants to crown size stays relatively constant. The net result was no detectable height growth in an even-aged stand. Barrett and Roth (1986) also investigated the response of a thinned stand of mistletoe-infected immature 40- to 70-year old ponderosa pine, and response of a thinned stand of mistletoe-infected immature ponderosa pine that had recently had a removal of mature mistletoe-infected overstory. Conclusions of these studies demonstrate that by regulating stand density, trees in even-aged stands are able to tolerate light to medium levels of dwarf mistletoe and grow at or near rates of uninfected trees.

Given its persistent nature, the best way to control dwarf mistletoe is to prevent infection by protecting young tree regeneration (Conklin 2000), through stand replacement disturbance or clearcutting. Spot treatment for protecting regeneration in irregular, and uneven-aged sites can help provide a more sustainable condition by reducing abundance or delaying infection. In uneven-aged stands with numerous scattered infections such as those found within the project area, regenerative conditions in the absence of disturbance or treatment deteriorate over time (USDA PNW BMZ-96-07, 1996). Where infection severity renders stand conditions unmanageable, more aggressive stand-replacing harvests may be called for (Gill and Hawksworth 1954; Hawksworth 1978). Regeneration occurring in openings under an uneven-aged management approach can be achieved through group selection, which controls mistletoe more effectively than single-tree selection, where infection can still occur beside infected trees. Treatment blocks should include groups of infected trees and a buffer of 100 feet beyond visibly infected trees. To minimize invasion of young pine stands by dwarf mistletoe from bordering infected trees, the ratio of perimeter to area of clearcuts should be minimized, with cut openings roughly circular, rather than long and narrow (Forest Insect and Disease Leaflet, USDA 2003). Two- to four-acre gaps in heavily infected uneven-aged stands are the recommended size to allow ponderosa pine regeneration to be free to grow in a relatively infection-free environment.

Table 3 and Table 4 illustrate findings from a 1990 Hawksworth study (“How Long Do Mistletoe-Infected Ponderosa Pine Live?”) on a relationship of tree growth and mortality in Arizona ponderosa pine to dwarf mistletoe infection. In the study, DMR was tracked by diameter class over a 30 year period. From the data in the tables, notice that the mean dwarf mistletoe rating increases faster for trees under nine inches than for those over nine inches. Also, those trees under nine inches with a DMR of 5 or 6 did not survive 30 years (Table 1).

Table 40. Trees/acre of Ponderosa Pines and 32-year Intensification in Relation to Original Dwarf Mistletoe Infection Rating Class and Diameter (from Hawksworth, 1990 on Arizona Ponderosa Pine)

Tree Diameter				
	Under 9 Inches in Diameter		9 inch Diameter and Over	
1950 DMR Class	Trees/acre Alive in 1982	Mean DMR in 1982	Trees/acre Alive in 1982	Mean DMR in 1982
0	88	1.8	199	1.1
1	19	4.3	53	3.7
2	14	5.1	40	4.9
3	4	5.5	25	5.2
4	2	6.0	16	5.4
5	0	-	15	5.8
6	0	-	3	6.0

Table 41. Trees/acre of Ponderosa Pines and Percent Survival after 11, 20, and 32 years in Relation to Original Dwarf Mistletoe Infection Rating Class and Diameter (from Hawksworth, 1990 on Arizona Ponderosa Pine)

Tree Diameter								
	Under 9 Inches in Diameter				9 Inches Diameter and Over			
1950 DMR Class	Trees/acre Alive in 1982	Percent Alive			Trees/acre Alive in 1982	Percent Alive		
		1961	1970	1982		1961	1970	1982
0-1	119	99	97	90	259	98	98	97

2-3	42	90	81	43	78	91	90	83
4-5	15	60	40	13	93	82	63	33
6	6	16	16	0	58	48	36	5

Retained in a passive management scenario without a frequent fire regime, dwarf mistletoe severity increases within the stand and spreads laterally to uninfected areas of the stand at a rate of one or two feet per year (Hawksworth 1996). This relationship is magnified for stands with a considerable uneven-aged structure and a large tree component. These effects are intensified, or more pronounced when the overstory trees are infected, causing not only a lateral, but also a vertical vector for spreading infection onto susceptible understory trees. Infected overstory trees are less likely to develop into mature trees as shown in Table 3, especially if the level of infection is severe (rated 5 or 6). Severe infection levels also serve as ladder fuel (facilitating transition from a low-intensity ground fire into a more lethal crown fire event), reduce the vigor of the older trees through competition, and make them more susceptible to attack from western and mountain pine beetle. These factors taken together reduce the potential for a stand to achieve old forest structure in a portion of the stand where the overstory infection occurs.

Figure 9 illustrates growth of trees correlated to the dwarf mistletoe rating over the course of 100 years. (Growth rates from Hawksworth, USDA Agriculture Handbook 709, 1996). An assumed linear growth rate of an uninfected tree that takes 100 years to reach 21 inches is compared to expected growth rates of differing DMR severity. Dwarf mistletoe not only reduces the number of trees that reach 21 inches but also increases the time it takes for individual trees to reach that size.

Figure 9. Relative Growth of Ponderosa Pine of differing Dwarf Mistletoe Infection Ratings